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Evaluation of Existing Marine Intertidal and Shallow Subtidal Biologic Data

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This report summarizes and compares methodologies used by the investigators who conducted the baseline studies and calls attention to problems in the data base resulting from methodological differences and other factors. Communities in three broad habitat categorizations--rocky intertidal, soft substrate intertidal, and subtidal--were examined by means of cluster analysis. For the intertidal habitats, numerical assemblage parameters such as richness, biomass, and diversity were computed and examined by means of multiple regression and analysis of variance to fulfill the first study objective. Key populations were analyzed similarly.

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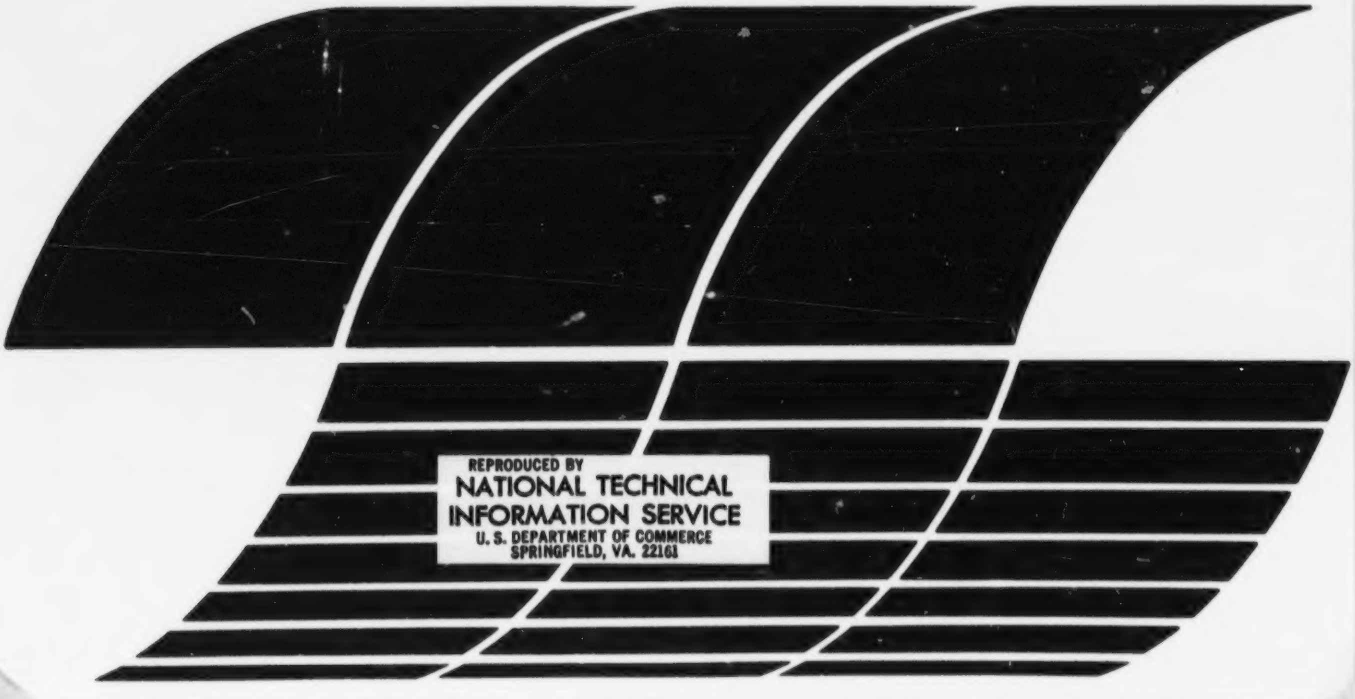

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AND SHALLOW SUBTIDAL BIOLOGIC DATA

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FOREWORD

Substantially increased petroleum tanker traffic and refining operations are anticipated in the region of northern Puget Sound and the Strait of Juan de Fuca as Alaskan crude oil production increases and as pipeline deliveries of crude from Canada to the region are terminated. This increased transport and refining activity will increase the opportunities for spills and leaks of crude oil and refined products into the marine environment. Recognizing the need for environmental information in the region, the U.S. Environmental Protection Agency has supported the Puget Sound Energy-related Project under which studies involving biological characterizations, physical oceanography, trajectory modeling, pollutant monitoring, and fate and effects of oil have been implemented. This Project has been administered by NOAA's Marine Ecosystems Analysis (MESA) Puget Sound Project office. A major part of the Project has involved a variety of biological studies intended to provide information on the characteristics of biological communities at risk to oil pollution in the region. This report presents the results of a study to determine the degree of variability, and thus, utility of existing biologic data which may be used to estimate oil spill impacts. Intertidal and shallow subtidal benthos data collected by investigators supported by the Project and by the Washington Department of Ecology were studied.

ABSTRACT

This study was initiated in order to evaluate a large set of marine intertidal and shallow subtidal biologic data collected in two baseline study programs in the marine waters of northwestern Washington between 1974 and 1979. These programs, sponsored by the U.S. Environmental Protection Agency and the State of Washington Department of Ecology, shared the objective of characterizing biologic communities which may in the future be subjected to stresses resulting from increases in oil shipment and refining operations in the region.

The first objective of the present study was to conduct statistical analyses of the baseline data to assess the contributions of annual, seasonal, tidal elevation, geographic, habitat, and between-sample variations to overall variability in the data and to determine the predictability of communities at future times and/or different sites from the existing data base. In the course of these analyses, the correctness and usability of the data tapes were also evaluated. The second objective of the study was to recommend strategies for future research (possibly including monitoring) to strengthen the data base.

This report summarizes and compares methodologies used by the investigators who conducted the baseline studies and calls attention to problems in the data base resulting from methodological differences and other factors. Communities in three broad habitat categorizations--rocky intertidal, soft substrate intertidal, and subtidal--were examined by means of cluster analysis. For the intertidal habitats, numerical assemblage parameters such as richness, biomass, and diversity were computed and examined by means of multiple regression and analysis of variance to fulfill the first study objective. Key populations were analyzed similarly.

Exposure, sediment characteristics, and tidal elevation proved to be the key contributors to variability in the data. However, there were strong site differences which could not be fully explained by these factors. In addition, the level of replication used in the baseline studies proved to be too low for reliable prediction and change detection. Our recommendations for future sampling call for increasing levels of replication by focusing on a smaller number of habitats and elevations. We also include suggestions for streamlining and standardizing sampling methodology.

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SECTION 1

INTRODUCTION

In the past decade, a remarkable number of "baseline" or "benchmark" surveys of littoral communities have been conducted in the marine waters of northwest Washington and elsewhere. This activity has been spurred by the National Environmental Policy Act (NEPA) and an increasing awareness of potential environmental consequences of man's activities in the coastal zone. In general, this type of survey has attempted to obtain replicated quantitative data on species abundance and distribution as well as total animal and/or plant density and weight (biomass), richness, and diversity.

The two primary objectives of these surveys typically have been (1) to characterize the nature and perhaps the resource value of communities observed and (2) to provide data that will allow testing of hypotheses regarding factors affecting patterns in space (e.g., habitat, elevation, location effects) or time (e.g., predisturbance/postdisturbance, seasonal, annual effects).

The first objective has been accomplished quite adequately by a variety of researchers (Houghton 1973; Houghton and Kyte 1978; Nyblade 1977, 1978, 1979a and b; Smith and Webber 1978; Smith 1979; Thom 1978; Wisseman et al. 1978; Webber 1979 and 1980). However, only infrequent attempts have been made at statistical testing of the significance of observed patterns and the suitability of the data obtained for detection of real differences in space or time or for prediction of biological characteristics of assemblages in like habitats at other locations.

The work presented in this report represents such an effort using intertidal and shallow subtidal data obtained in two large-scale and long-term sampling programs. The first was funded by the State of Washington Department of Ecology (WDOE), the second by the U.S. Environmental Protection Agency (EPA) through the Puget Sound Project Office of the Marine Ecosystems Analysis (MESA) program of the National Oceanic and Atmospheric Administration (NOAA). NOAA also administered the study reported in this document.

1.1 THE DATA BASE

The WDOE North Puget Sound Baseline Studies Program (BSP) was begun in 1974 to develop, among other things, a "continuing comprehensive program of systematic baseline studies to...use as supporting evidence of environmental damage resulting from oil pollution..." (Gardner 1978). Specific objectives governing the implementation of the intertidal and shallow subtidal (littoral) studies evaluated in this report were (Gardner 1978) to:

> "Document the distribution and abundance of biological resources and relevant oceanographic parameters in intertidal and shallow subtidal habitats."

and

> "Determine the distribution and abundance of intertidal and shallow subtidal populations of Significant Biological Resources which serve as major sources of recruitment for adjacent areas."

Field studies of intertidal and shallow subtidal biota were conducted in North Puget Sound* from the summer of 1974 through the summer of 1976. Additional summer sampling continued at some sites through 1980. Two different investigators performed the field investigations in two different geographic locales: Dr. Carl Nyblade of the University of Washington Department of Zoology worked primarily on San Juan Island, and Dr. Herbert Webber of Western Washington University worked in the bays and islands east of Rosario Strait and along the east shore of the Strait of Georgia.

Each investigator initially employed different sampling strategies, with Nyblade (1977) using a stratified random design and Webber (Smith and Webber 1978) using a gradient sampling technique. Beginning with sampling in 1975, an effort was made to standardize techniques to obtain more comparable data from each locality.

In 1975, EPA initiated a series of nationwide environmental research programs designed to identify the potential ecological and health impacts of accelerated energy development. The inland waters of northwestern Washington were selected for one of these programs as an area likely to be affected by intensified petroleum shipping and refining operations. The NOAA/MESA Puget Sound Project Office was selected to manage the study. The overall objectives of this research relevant to the present study were to:

1. Characterize the major marine biological populations subject to impact by pollution resulting from petroleum transportation and refining activities in the Puget Sound region, and

2. Provide decision-makers with environmental and ecological information and predictions of the effects of oil-related activities upon the ecosystem.

---

*The term "North Puget Sound" as used in this report is geographically inaccurate; the area referred to includes the San Juan Islands and the inland waters in the approaches to Rosario Strait and adjacent to the mainland from north of Whidbey Island up to the southern end of the Strait of Georgia. We use the term North Puget Sound (or northern Puget Sound) to be consistent with previous studies and the guidelines for this study.

The MESA program's intertidal and shallow subtidal baseline field studies began in 1976. The same two investigators were contracted. General methods used for intertidal studies were standardized, including both gradient and stratified random measurements. Again, however, each investigator was responsible for a separate geographic region. In addition, the two-year sampling program on Whidbey Island began a year after the start of the two-year program in the Strait of Juan de Fuca. Subtidal methods varied between the researchers.

In short, the WDOE and MESA studies in the Puget Sound region were begun in response to the same basic need. They shared the objective of characterizing biologic communities that may in the future be subjected to stresses resulting from expected increases in oil tanker traffic, refinery operations, and pipeline development. While there were variations in methodology within and between the baseline programs, an attempt was made to standardize sample collection and laboratory analysis techniques to obtain comparable data. The data collected comprise the data base for the present study.

The 30 sites sampled most intensively during the WDOE and MESA studies are shown in Figure 1. These sites represent rock, cobble, gravel, sand, mud, and mixed habitats. Additional locations were sampled only once or a few times.

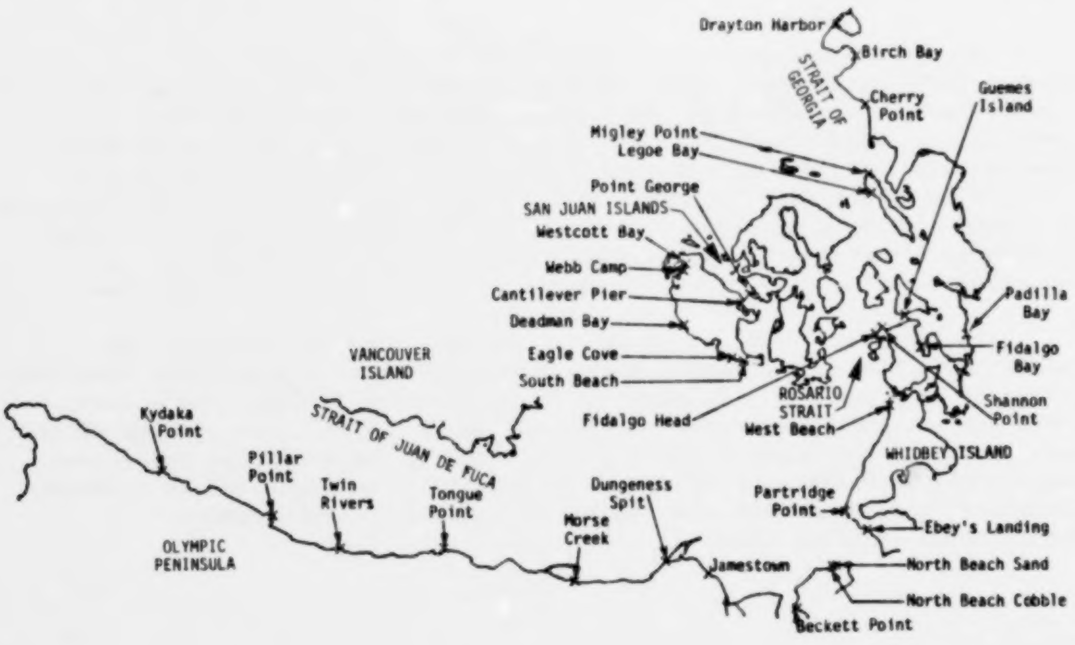
Drayton Harbor
Birch Bay
STRAIT OF GEORGIA
Cherry Point
Guemes Island
Migley Point
Legoe Bay
Point George
SAN JUAN ISLANDS
Westcott Bay
Webb Camp
Cantilever Pier
Deadman Bay
Padilla Bay
Fidalgo Bay
VANCOUVER ISLAND
Eagle Cove
South Beach
ROSARIO STRAIT
Shannon Point
Kydaka Point
STRAIT OF JUAN DE FUCA
Fidalgo Head
West Beach
WHIDBEY ISLAND
Pillar Point
Twin Rivers
Tongue Point
Dungeness Spit
Partridge Point
Ebey's Landing
Morse Creek
OLYMPIC PENINSULA
Jamestown
North Beach Sand
North Beach Cobble
Beckett Point

Figure 1. Intertidal and shallow subtidal baseline study sites.

1.2 NEED FOR THE PRESENT STUDY

The marine waters of Washington have not yet been subjected to massive oil spills or to the environmental problems associated with continued release of small amounts of oil. Hence, the baseline data described above represent an "unstressed" environment. In the event of an oil spill or other perturbation, these data would be used to help determine changes in affected communities.

An overall examination of the data was considered necessary to determine the adequacy of the data base for defining the unperturbed communities and permitting the detection of changes. If the existing data proved inadequate, the present study was to recommend further sampling to strengthen the data base. Events such as Canadian reductions in the amount of crude oil piped into the United States and increases in the flow of Alaska crude make increased petroleum shipping and refining operations in the greater Puget Sound region in the near future a virtual certainty. Hence, the present study was needed now to permit any further sampling determined necessary under baseline conditions.

If a perturbation were to affect a specific site for which historical biologic data were available, those data could be used directly in estimating changes. If, however, areas never studied were affected, estimates of change would have to be based upon extrapolation of existing data from nearby sites of similar habitat type. In either case, the accuracy of estimates of change would depend directly upon the statistical strength of the existing data set.

The data examined in this study were archived on National Oceanographic Data Center (NODC) intertidal/subtidal File 100 format magnetic tapes. Such tapes were produced for the NOAA/MESA studies by the investigators under contract. The data collected under contract to WDOE between 1974 and 1976, however, were archived in File 100 format only in 1979. This is the first study to attempt site comparisons and other analyses involving both WDOE and MESA data and using the associated File 100 tapes. Therefore, the present study is also important from the standpoint of determining whether the File 100 tapes contain correct and usable data.

The present study was needed to compare sites representing the different habitats, geographic areas, and investigators previously described primarily on a site-by-site basis in the reports of Nyblade (1977, 1978, 1979a and b), Smith and Webber (1978) and Webber (1979, 1980). Some of the baseline data, for example the data collected by Webber during the second year of the WDOE study, have never been presented or discussed in reports; therefore, this study was also needed to provide at least summary descriptions of these data.

1.3 STUDY OBJECTIVES

The objectives of the present study are to

1. Provide a statistical basis for assessing future changes in community structure at any site in the study area (assuming that identical field and laboratory methods would be used in the future).

   a. Determine the degree of variability in data for each habitat type, where annual, seasonal, tidal elevation, and between-sample variations are considered.

   b. Determine the confidence with which site-specific data can be used to estimate community changes at historically sampled locations. Document trends, if any, in the relative statistical strength of the data per habitat type.

   c. Determine if biota observed at two (or more) nearby sites of each habitat type are similar and if the data from these sites can be used to estimate the biota at nearby unobserved sites of similar habitat. Report on the degree of confidence that can be associated with the estimates. Determine the applicability of data collected from the Strait of Juan de Fuca, Whidbey Island, San Juan Islands, and northern Puget Sound (Bellingham-Anacortes) areas to each of the other areas on a habitat basis; and the degree of confidence associated with each application.

   d. Determine the relative importance of tidal elevation and habitat type upon variability.

2. Develop a sampling strategy for further monitoring, if necessary, of previously studied and/or new sites to strengthen the overall data base. Recommend minimum sampling frequency, sample numbers, sample types, strata, and analyses per habitat type. Provide a statistical basis for the recommended sampling strategy.

In Sections 2 and 3 we summarize our conclusions and recommendations regarding these objectives. Section 4 discusses the methods used to obtain the data base from which our conclusions were drawn and some of the resulting data problems. Section 5 outlines our approach to the data analyses required to satisfy Objective 1, and Section 6 presents the detailed results of these analyses. In Section 7 we detail our Objective 2 recommendations. Section 8 contains suggestions for additional analyses of the available baseline data and data to be collected in the future.

SECTION 2

CONCLUSIONS

A major conclusion of this study is that the data base is weak in several important respects. First, many subsets of the data do not exist on File 100 tapes, and those that are on tape contain many errors. Second, those subsets that were completely and correctly recorded on tape often proved inadequate to support predictive models because of low levels of replication and inconsistencies in sampling methodology and taxonomy.

The available data were grouped into four broad habitat categories for purposes of analyses although more specific habitat types were considered in the WDOE and MESA studies. Our analysis categories were rocky intertidal, soft substrate intertidal, cobble intertidal, and subtidal. Communities were examined using cluster analyses and analyses of numerical assemblage parameters such as richness and diversity. Major populations were also examined. Within each habitat there were strong site differences that could not be fully explained by the available data on sediment size, exposure, and other physical characteristics of the sites. Thus, the prognosis for estimating the biota at unobserved sites from data at nearby observed sites of similar habitat is rather poor, although exceptions will be noted below.

In the rocky intertidal habitat, tidal elevation proved to be the dominant factor contributing to variability, with elevation effects varying among sites. Within a given stratum of elevation the two sites in the Strait of Juan de Fuca were relatively similar to each other and quite different from the North Puget Sound sites. The North Sound sites were also fairly similar to each other. The Strait sites represent a more exposed habitat than the North Sound sites, and exposure influences the elevation at which particular assemblages are found, accounting for the large between-region differences.

Some seasonal and year-to-year differences were detected in such assemblage parameters as species richness, especially when spring data were considered. However, seasonal effects at a given site generally accounted for less than 5 percent and year-to-year changes less than 10 percent of the variability in assemblage parameters, with elevation effects being much more significant. Site and season differences made roughly the same contributions to variability within an elevation stratum in the Strait, but site differences dominated season differences in the northern Sound. Shorter term (within season) variability was generally insignificant.

Power calculations discussed in Section 6.1.3 indicate that with the level of replication used in the Baseline Studies Program and the observed replicate (between-sample) variability, changes in most assemblage parameters must be of the order of 50 percent to 100 percent or more if they are to be reliably detected. Changes of this order in log transformed counts of some of the most common animal species are also detectable, but changes in weights of particular plant species are, for all practical purposes, undetectable.

In spite of the rather low probability of detecting small changes provided by the baseline data, some significant year-to-year and site-to-site differences were found in these parameters under baseline (unperturbed) conditions. Hence the prognosis for cross-site prediction is poor, and even community changes detected at historically sampled sites, seasons, and tidal elevations cannot automatically be attributed to known perturbations such as oil spills. Physical, chemical, and biological as well as statistical analyses are needed to determine causes of observed changes.

Among the assemblage parameters, animal richness and diversity appeared to be most useful for prediction. These parameters did not differ significantly, for example, in high elevation summer data collected between 1976 and 1978 at Fidalgo Head and Cantilever Pier. Limpets, periwinkles, and barnacles proved to be the most predictable individual organisms, with less variability at the genus than at the species level. However, more replicates per site/season/elevation are needed if an accurate assessment of predictability of either assemblage parameters or particular populations in rocky intertidal habitats is to be made.

At soft substrate intertidal sites, exposure proved to be the key factor contributing to variability. Substrate, geographic region, and tidal elevation influenced soft substrate assemblages as well, but their effects were difficult to separate from exposure effects. Thus the characterization of habitat type in terms of substrate (gravel, sand, mud) used in the Baseline Studies Program proved to be less useful for categorizing soft substrate sites than a characterization in terms of exposure. However, substrate characteristics appeared to outweigh tidal elevation in importance since the most significant "elevation" effects occurred at sites where sediment composition changed greatly with elevation, and sites with uniform sediment often showed no significant differences between elevations.

Our analyses pointed to a division of the baseline sites into a highly exposed group consisting of most of the sand and gravel sites in the Strait of Juan de Fuca and West Beach on Whidbey Island, a moderately exposed group (the North Beach sand site in the Strait, the Ebey's Landing gravel site on Whidbey, and the San Juan Island sand and gravel sites Eagle Cove and Deadman Bay), a moderately protected group consisting of the North Sound sites Birch Bay (sand) and Guemes Island South (gravel), and a protected group containing the remaining soft substrate sites. Substrates in the latter group were mud or mixed fine; the percent of fine sediment (silt size or smaller) is a function of exposure. Thus, the protected group can be characterized in terms of substrate while the more exposed groups, all consisting of sites with sand and/or gravel sediments, cannot.

At the most exposed sand and gravel sites, changes in the sparse and extremely variable fauna cannot be reliably detected with reasonable levels of replication. Changes over time were detected in population and assemblage parameters in the moderately exposed and moderately protected groups, and similarities between sites were generally too low to permit cross-site prediction.

At the most protected mud and mixed fine sites, polychaetes, bivalves, and amphipods occurred regularly in large numbers. However, particular species that were found varied considerably over time and from site to site, making reliable predictions impossible, at least with the level of replication used in the baseline studies. Replicate variability in counts of almost all of these animals dictated that 15 or more samples per site/season/elevation would have to be collected to permit reliable detection of 50 percent changes in means of log transformed counts. No plant species were found regularly. Hence, it is unlikely that parameters of particular plant and animal populations could be used for purposes of damage assessment following a perturbation such as an oil spill given the present baseline sampling methodology.

Assemblage parameters appeared to be predictable and therefore usable for damage assessment within a well-defined habitat type and geographical area for the protected habitats. For example, summer 1976 Webb Camp data from low to mid elevations were usable for predicting summer 1977 and 1978 means of animal richness and diversity at low to mid elevations at Westcott Bay. However, more data on physical parameters than are available in the present data base would be required to permit a previously unobserved site to be categorized by habitat type.

As in the rocky intertidal habitat, animal richness and diversity were the most useful parameters. Changes of 50 percent or less in means of these parameters at protected mud and mixed fine sites were detectable with 90 percent probability even with only three replicates per site/season/elevation. Smaller changes in log transformed total animal counts were readily detectable, but such changes occurred under baseline conditions at soft substrate sites, particularly when samples taken two years apart in time were compared.

Detailed analyses of cobble intertidal data were not conducted. The complex and varying sampling techniques used in cobble habitats led to errors and problems in the data, which made quantitative analysis difficult. Because cobble habitats comprise only a small percent of the shoreline in the study region, we concluded that the considerable effort involved in collecting and analyzing cobble data could be better spent on the more common habitats. However, it should be noted that some cobble sites were among the most productive biologically, with very high animal density and biomass. Further analysis of data from some of these sites might be useful if funding is available.

Variations in sampling methodology and data errors also made analysis of the subtidal data difficult. However, we concluded from cluster analyses of the data that sediment characteristics and exposure are the dominant factors affecting variability in subtidal habitats. Depth effects appeared to be relatively unimportant below 5 meters (m), and similarities among sites of similar substrate were high below that depth, suggesting that the definition of habitat in terms of substrate for predictive purposes may be more successful subtidally than intertidally.

However, clustering by year and season in some of the subtidal dendrograms indicates that, as in the intertidal habitats, changes in communities occur naturally through time, so statistical analysis alone may be inadequate to determine the effects of a perturbation such as an oil spill. More quantitative analyses of subtidal assemblage and population parameters are needed before final conclusions can be drawn concerning the possibility of prediction and change detection in subtidal habitats of the Puget Sound region.

SECTION 3

RECOMMENDATIONS

A major objective of this study was to recommend sampling strategies and methods for further baseline or monitoring programs in the Puget Sound region. Our recommendations for baseline sampling, as well as strategy and methodology for assessing effects of oil spills, are detailed in Section 7 of this report. We begin this section by summarizing the recommendations of Section 7 and conclude it with a set of recommendations for improvements which could be made in the present baseline data set without additional sampling.

We recommend that future sampling efforts be directed toward stations where there are existing data, ones where risk of oil spills is great, and/or ones which can serve as controls for impacted sites. Sites sampled should also be those that are more protected and thus have greater vulnerability to spills; exposed sand, gravel, and cobble have both low vulnerability and a depauperate fauna. Areas sampled should be accessible to study, be "typical" of as great a percentage of shoreline as possible, and offer a large expanse of relatively uniform habitat for sampling. We also suggest that future monitoring be preceded by a meeting of past investigators, the present study team, and MESA and WDOE scientists to evaluate suitable sites.

Because of the naturally high variability of populations of organisms, the level of replication used in the baseline sampling that produced the data base analyzed in the present study was frequently inadequate. Our major recommendation is an increase in replication to ensure a reasonable probability of detecting changes. To make this increase possible within constraints of time and funding, we have suggested concentrating sampling efforts within a single intertidal elevation stratum (the mid tide range) of the more sensitive, protected habitats and in a single subtidal depth range (between 5 m and 10 m). To further focus available effort, sampling during spring and fall, periods of high rates of change, should be dropped in favor of summer and perhaps winter sampling. WDOE has wisely chosen to focus their limited resources on summer sampling since 1976.

We recommend some departures from the techniques used in the WDOE and NOAA/MESA baseline studies to streamline or standardize future intertidal monitoring. For example, we recommend that more percent cover data for plants and encrusting organisms be collected. Although the limited amount of percent cover data available in the present baseline data set did not prove useful for prediction and change detection, this parameter has been employed successfully in other sampling programs (Lees et al. 1980).

In rocky habitats we suggest identifying and enumerating only organisms 3 millimeters (mm) or larger, in part to minimize taxonomic problems with smaller animals. For continuity on soft substrates we suggest maintaining the sieve sizes used in the WDOE and MESA studies. However, we recommend using smaller core samplers to achieve higher replication for infauna and adding large quadrats for measuring cover, density, and/or biomass of kelps and sea grasses where they are important.

Statistical conclusions for subtidal areas were severely limited by data errors and lack of standardization of sampling techniques. Because of this, we recommend the use of standardized techniques for future subtidal sampling. Subtidally, we recommend using techniques similar to those used intertidally except that in rocky or kelp bed areas, larger quadrats should be used to enumerate larger animals and plants. On soft sediments an airlift sampler is recommended for the larger "live sieve" cores while the smaller cores (1 mm sieve) can be readily taken by a diver.

As noted in Section 2, better data on physical parameters at soft substrate intertidal and subtidal sites are needed to permit categorization by habitat for predictive purposes. We recommend that future soft bottom baseline sampling include at least two replicate sediment size samples taken at the times and tidal elevations or depths at which stratified biological samples are taken, at least until repeated sampling has shown that sediment composition is stable at a site. Chemical parameters should also be measured. We recommend that the File 100 Habitat Code be used to characterize such factors as wave energy and beach gradient.

Methodologies which we propose for monitoring oil spill impacts, discussed in Chapter 7, include a pre-oiling assessment (if time and logistics permit), an initial spill assessment soon after oiling, short-term post-spill reassessment, and long-term recovery monitoring.

Before another sampling program is begun we suggest one-time field tests involving several of the conclusions and recommendations of this analysis. These tests should include collection and analysis of 25 replicates at the mid tide level of a protected rocky, a protected mud flat, and a protected mixed habitat. Nested box sampling should be used to evaluate the adequacy of selected quadrat and core sizes. Subtidally, a comparison of surface (van Veen) grab sampling and SCUBA airlift sampling would be desirable on both sand and mud bottoms. The data collected should be used to construct species-area curves and perform analyses of variance to examine the stability of variance of assemblage and population parameters. Because collection, handling, processing, and taxonomy would be uniform, such an effort would provide a much more reliable estimate of true variability and ability to detect change than it has been possible to gain from the existing baseline data set.

A number of improvements to the existing baseline data set can be made without additional sampling. Correction of the most serious errors in the data base (see, for example, Zeh 1980e) is of highest priority. We strongly recommend that the data of Nyblade (1979b) be added to the File 100 data base since they represent more recent samples than those presently on tape for several northern Puget Sound sites and, in addition, the only sites sampled independently by both Nyblade and Webber. The data collected for WDOE during the summers of 1979 and 1980 should also be archived on File 100 tapes.

Addition of correct habitat codes to records in which they are missing or incorrect would facilitate the classification of sites by habitat for predictive purposes. Uncombined rock and cobble data which have not been put on tape could also be added to the data base to enable more complete analyses of subsampling variability to be performed. However, these additions are less crucial than the additions and corrections suggested in the previous paragraph.

To avoid serious errors and omissions in data collected in future sampling programs, several revisions to File Type 100 specifications would be beneficial. See Section 4.2.3 and Zeh (1980a). Many problems in archived data could be avoided by requiring timely submission of data tapes and using the submitted tapes to perform statistical analyses as well as checking them for obvious errors such as illegal taxonomic codes. Taxonomic code problems could be mitigated by being sure investigators are provided with a current NODC taxonomic code dictionary and easy mechanisms for adding new species to this dictionary. It has been our experience that such additions often require more than two years. It would also be helpful to include taxon name as well as code on File 100 Species Identification records to simplify correction of errors.

Several additional analyses of the existing data (after correction of errors) which were impossible to complete during the present study due to time and funding constraints should be carried out. Species-area curves should be plotted. Nested analyses of variance should be carried out to assess subsampling variability and the adequacy of smaller samples in those subsets of the data base for which subsamples are available on tape, for example, the second year soft substrate subtidal data and intertidal rock and cobble data from the Strait. Analyses of variance and perhaps other quantitative statistical analyses of all the subtidal data should also be performed. These additional analyses would permit refinement of recommended sampling methodologies before additional sampling is carried out so that future sampling could indeed strengthen the overall data base, making it more useful for assessing community changes caused by oil spills or other perturbations.

SECTION 4

DISCUSSION OF THE DATA BASE

The data base considered in the present study consists of data from the 30 baseline study sites shown in Figure 1. The dates at which samples were collected at these sites are shown in Table 1. The sites in this table are categorized by habitat and region/investigator. In this and subsequent tables and discussions the North Puget Sound sites sampled by Webber for WDOE are labelled "NPS". Nyblade WDOE sites are denoted by "SJI"; all are on San Juan Island except the rocky subtidal site, Point George, on Shaw Island. "Strait" denotes Nyblade MESA sites in the Strait of Juan de Fuca, while "Whidbey" denotes the Whidbey Island sites sampled by Webber for MESA.

The methods used by Nyblade and Webber to collect the samples yielding the data sets examined in this document strongly influence the statistical analyses and predictive models the data can support. Therefore, in this section, we first describe and compare these methods. Then we discuss the types of problems that were encountered in our analyses as a consequence of various aspects of the studies.

4.1 METHODS OF DATA COLLECTION AND REDUCTION

Methods used to obtain data from the varied intertidal and shallow subtidal habitats of the study areas can be categorized by habitat. The four broad habitat types relevant to this categorization are:

a. Intertidal rock,
b. Intertidal soft substrates,
c. Intertidal cobble, and
d. Subtidal substrates.

The marked differences in substrate types and biological assemblages dictated the use of a wide variety of sampling techniques. Furthermore, differences in perception, experience, and interpretation among the investigators led to varying approaches. In an attempt to facilitate description and comparison of the strategies and methodologies employed, we have prepared tables summarizing the methods for each substrate. These tables have been heavily footnoted to indicate such things as differences in sieve size and amount of replication among the investigators.

TABLE 1. SAMPLING DATES AT BASELINE STUDY SITES

HABITAT	SITE (REGION/INVESTIGATOR)*	1974						1975											
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Rock	Fidalgo Head (NPS)				15 G		29 G		22 G		29 G		26 G		7 G			4 S	
	Migley Point (NPS)					29 G		28 G		31 G		27 G		11 G		3 G			
	Cantilever Pier (SJI)			11 S		30 S		26 S		31 S		26 S		9 S		2 S		4 S	
	Point George (SJI)					27			6	11		1							
	Tongue Point (Strait)																		
	Pillar Point (Strait)																		
Cobble	Cherry Point (NPS)				14† G		12 G		23 G		28 G			7 G	5 G			5 S	
	Shannon Point (NPS)					14 G		27 G		29 G		14 G		22 G		4 G			
	South Beach (SJI)		15 S		31 16S		27 S		19 S		26 S		24 S		7 S				
	North Beach (Strait)																		
	Morse Creek (Strait)																		
	Partridge Point (Whidbey)																		
Gravel**	Guemes Island, South (NPS) (pebble)				30 G		14 G		24 G		18 G		19 G		4 G			6 S	
	Legoe Bay (NPS) (pebble)					15 G			8 G	20 G		16 G		21 G		1 G			
	Webb Camp (SJI) (protected gravel)		16 S		16	2 S	29 S		18 S		29 S		25 S		5 S		7 G		2 S
	Deadman Bay (SJI) (exposed gravel)	16 S		13 S	16	29 S		25 S		27 S		13 S		11 S		4 S		3 S	
	Beckett Point (Strait) (gravel/sand/mud)																		
	Dungeness Spit (Strait) (exposed gravel)																		
	Twin Rivers (Strait) (exposed gravel)																		
	Ebey's Landing (Whidbey) (gravel)																		
Sand	Birch Bay (NPS) (sand)				31 G			10 G	21 G		15 G		24 G		6 G			3 S	
	Eagle Cove (SJI) (exposed sand)			12 S	16		1 S	27 S		28 S		27 S		10 S		3 S			
	North Beach (Strait) (exposed sand)																		
	Kydaka Beach (Strait) (exposed sand)																		
	West Beach (Whidbey) (sand)																		
Mud	Fidalgo Bay (NPS) (mud)					4† G		12 G	7 G			15 G	25 G		8 G			24 S	
	Drayton Harbor (NPS) (mud)					16 G		25† G			17 G		23 G	10 G		2 G			
	Padilla Bay (NPS) (mud)				21 G		11 G		25 G		16 G			8 G	18 G				
	Westcott Bay (SJI) (protected mud)		17 S		16	1 S	28 S		17 S		23 S		23 S		6 S		8 G		1 S
	Jamestown (Strait) (sandy mud)																		
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
		1974						1975											

TABLE 1 (Continued)

HABITAT	SITE (REGION/INVESTIGATOR)*	1976 J	F	M	A	M	J	J	A	S	O	N	D	1977 J	F	M	A	M	J	J	A	S	O	N	D
Rock	Fidalgo Head (NPS)	4 G	2† S	20		13 S		9 G	6 S	17															
	Migley Point (NPS)																								
	Cantilever Pier (SJI)			19 S		15 S		10 G		2 S											26‡ S				
	Point George (SJI)																								
	Tongue Point (Strait)					1 S		3,11 S,G			27 S			18 S				6 S17	30 S				16 S		
	Pillar Point (Strait)					15 S	3		9 S,G			22 S		19 S				5 S	22						
Cobble	Cherry Point (NPS)	15 G	13 S	16		14 S		9 G	7 S	9															
	Shannon Point (NPS)																								
	South Beach (SJI)																								
	North Beach (Strait)				19 S		2	9 S,G			25 S	24 S		6 S			7 S		24						
	Morse Creek (Strait)					17 S	3	27 S,G				23 S		17 S				4 S	7	28 S				13 S	
	Partridge Point (Whidbey)																8,30 S		30 S		26		18 S	8	
Gravel**	Guemes Island, South (NPS) (pebble)	15 G	11 20S			11 S		23 G	5 S	11															
	Legoe Bay (NPS) (pebble)																								
	Webb Camp (SJI) (protected gravel)				16 S		12 S		7 S																
	Deadman Bay (SJI) (exposed gravel)	15 S		22 S		16 S		11 G		3 S											25‡ S				
	Beckett Point (Strait) (gravel/sand/mud)				16 S		2	12 S,G			27 S	19 S		7 S			6 S		6	1 S			19 S	14 S	
	Dungeness Spit (Strait) (exposed gravel)					14 S	2	25 S,G				21 S		5 S				7 S	7	27 S				12 S	
	Twin Rivers (Strait) (exposed gravel)					16 S	4,14	28 S,G				24 S		21 S				3 S	22						
	Ebey's Landing (Whidbey) (gravel)																7,28 S			1 S	22		17 S	3†	
Sand	Birch Bay (NPS) (sand)	17 G	14 S	3		12 S		12 G	8 30,S																
	Eagle Cove (SJI) (exposed sand)	16 S				14 S		8 G		1 S											24‡ S				
	North Beach (Strait) (exposed sand)					13 S	2	26 S,G				25 S		16 S				8 S	24	29 S				15 S	
	Kydaka Beach (Strait) (exposed sand)				17 S		3	10 S,G			26 S			20 S			5 S		29 21 S				15 S		
	West Beach (Whidbey) (sand)																6,19 S			2 S	10		15 S	18†	
Mud	Fidalgo Bay (NPS) (mud)	19 G	15 S	19		17 S	13† G		9 S	17															
	Drayton Harbor (NPS) (mud)																								
	Padilla Bay (NPS) (mud)																								
	Westcott Bay (SJI) (protected mud)				17 S		11 S		6 S												27‡ S				
	Jamestown (Strait) (sandy mud)				18 S		2	8,13 S,G			24 S			4 S			8 S		7,28 S				17 S		
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
		1976												1977											

TABLE 1 (Continued)

	HABITAT SITE (REGION/INVESTIGATOR)[*]	1978												1979	
		J	F	M	A	M	J	J	A	S	O	N	D	J	F
Rock	Fidalgo Head (NPS)														
	Migley Point (NPS)														
	Cantilever Pier (SJI)								17[‡] S						
	Point George (SJI)														
	Tongue Point (Strait)	8 S													
	Pillar Point (Strait)														
Cobble	Cherry Point (NPS)							20[‡] S							
	Shannon Point (NPS)														
	South Beach (SJI)														
	North Beach (Strait)														
	Morse Creek (Strait)		6 S												
	Partridge Point (Whidbey)	8 S	6		27 S	16	22 S	1			19 13S			27 22S	
Gravel[**]	Guemes Island, South (NPS) (pebble)							18[‡] S							
	Legoe Bay (NPS) (pebble)														
	Webb Camp (SJI) (protected gravel)														
	Deadman Bay (SJI) (exposed gravel)								15[‡] S						
	Beckett Point (Strait) (gravel/sand/mud)	11 S													
	Dungeness Spit (Strait) (exposed gravel)	9 S													
	Twin Rivers (Strait) (exposed gravel)														
	Ebey's Landing (Whidbey) (gravel)	7 S	13		26 S	8	21 30S				18 12S			26 18S	
Sand	Birch Bay (NPS) (sand)							19[‡] S							
	Eagle Cove (SJI) (exposed sand)								18[‡] S						
	North Beach (Strait) (exposed sand)	10 S													
	Kydaka Beach (Strait) (exposed sand)		8 S												
	West Beach (Whidbey) (sand)	6 24S			25 18S		20 29S				17 14S			25 21S	
Mud	Fidalgo Bay (NPS) (mud)							21[‡] S							
	Drayton Harbor (NPS) (mud)														
	Padilla Bay (NPS) (mud)														
	Westcott Bay (SJI) (protected mud)								16[‡] S						
	Jamestown (Strait) (sandy mud)	6 S													
		J	F	M	A	M	J	J	A	S	O	N	D	J	
		1978												1979	

[*] (NPS) denotes North Puget Sound sites sampled by Webber for WDOE. (SJI) denotes San Juan Island sites sampled by Nyblade for WDOE. (Strait) denotes sites in the Strait of Juan de Fuca sampled by Nyblade for NOAA/MESA. (Whidbey) denotes Whidbey Island sites sampled by Webber for NOAA/MESA.

[†] Discrepancy between date given in reports and date appearing on File 100 tapes. The tabled date is the one used in analysis.

[‡] Samples collected by Nyblade (1979b) for WDOE during the summers of 1977 and 1978 to extend the data base obtained earlier in the Baseline Studies Program. These data have not been archived on File 100 tapes and were used only for model verification in the present study.

[**] We include among the gravel sites some such as Guemes Island, Webb Camp, and Beckett Point which were alternatively characterized as "mixed fine." The habitat label given in Table 1 for all soft substrate sites (sand and mud as well as gravel) is that used by the investigator who sampled the site in his earliest report on the data.

G under a date indicates that intertidal gradient sampling was done on that date.

S similarly indicates intertidal stratified sampling. Note that although the stratified methodology was used for all Whidbey Island sampling, strata were at 1' increments for summer and winter sampling, no vertical distributions or organisms were determined.

Underlined dates are subtidal sampling dates. We have omitted from Table 1 dates corresponding to samples which were not processed by the investigators.

4.1.1 Sampling Strategies

The two basic strategies employed throughout these investigations were "gradient" sampling and stratified random sampling. The primary objective of gradient sampling, employing limited numbers of replicated samples distributed at close intervals across the vertical elevation gradient, is to define the vertical distribution patterns (zonation) of the major organisms and assemblages in a study area. Hence it is useful at the beginning of sampling in a new area, especially on soft substrates where the distribution and composition of biological assemblages are not obvious and clearly defined.

The main objective of stratified random sampling, employing larger numbers of replicated samples within major assemblages, is to estimate abundance, cover, and biomass levels of a large proportion of the organisms in each of several predetermined, identifiable assemblages (or zones) in a study area, and furthermore, to provide estimates of variability in these parameters. It is the appropriate strategy for providing a data base that permits detection of environmental change.

During the early sampling programs in North Puget Sound, Smith and Webber (1978), primarily used the gradient sampling strategy, whereas Nyblade (1977) used a stratified random sampling approach. Subsequently, Nyblade (1977,1978) occasionally utilized the gradient approach at SJI and Strait sites to provide data comparable to Webber's gradient data, thus permitting an evaluation of the vertical distribution patterns of intertidal biological assemblages in the inland waters of northwestern Washington. Moreover, Smith and Webber (1978) subsequently commenced using a stratified sampling strategy at their NPS study sites, and Webber (1979,1980) primarily used that sampling strategy on Whidbey Island.

4.1.2 Sampling Techniques

Intertidal Rocky Substrates:

Long-term studies were conducted on intertidal rock habitats at five sites in North Puget Sound and the Strait. The sites included Cantilever Pier, San Juan Island; Migley Point, Lummi Island; Fidalgo Head, Fidalgo Island; and Tongue Point and Pillar Point on the Olympic Peninsula. (Figure 1 and Table 1.)

The sampling techniques used on intertidal rock habitats, detailed in Table 2, basically fall into three categories of quadrat sampling:

1. Visually estimating the relative cover of dominant algae;

2. Manually scraping algae and small, cryptic or encrusting invertebrates from the rock surface for identification, weighing, and counting; and

3. Removing larger motile invertebrates from quadrats to permit their identification and enumeration.

TABLE 2. SUMMARY AND COMPARISON OF SAMPLING METHODS IN ROCKY INTERTIDAL SURVEYS

	North Puget Sound			Strait			
	Nyblade 1977	Smith and Webber 1978	Nyblade 1979	Nyblade 1978			Nyblade 1979
Strategies and Techniques	7/74 - 9/76	10/74-8/76	8/77, 8/78	Sp 76/W 77			4/77-2/78
Stratified Random Sampling							
Number of Levels	3	3	3	3			3
				Sp,F	S	W†	
Number of 0.25-m^2 quadrats examined/ level	4	3-5	4	4	2	4	4
Algae cover quadrats/level	0	0	0	4	2	4	0
Number of 0.25-m^2 algal scrapes/ 0.25-m^2 quadrats	1	1	1	1	1	0	1
Number of 0.20-m^2 algal scrapes/ 0.25-m^2 quadrats	0	0	0	0	0	1	0
Number of 0.01-m^2 algal scrapes/ 0.25-m^2 quadrats	5	5	5	5	5	5	5
Number of 0.25-m^2 invertebrate removals/quadrat*	1	1	1	1	1	0	1
Number of 0.20-m^2 invertebrate removals/quadrat*	0	0	0	0	0	1	0
Number of 0.01-m^2 invertebrate removals/quadrat	2-5	5	5	5	5	5	5
Number of survey periods in which this strategy was used	13	4	2	2	1	1	4
Gradient Sampling							
Number of transects/site and sampling elevations	2 or more; 8',7',6', 5',4',3', 2',1',0',-1'	2; 8',7',6', 5',4',3', 2',1',0',-1'	0	2 or more; 7',6',5', 4',3',2', 1',0'			0
Number of 0.25-m^2 algal scrapes/ transect	10	10	0	8			0
Algal cover quadrats/transect	0	0	0	8			0
Number of 0.25-m^2 algal scrapes/ 0.25-m^2 quadrat	1	1	0	1			0
Number of 0.01-m^2 algal scrapes/ 0.25-m^2 quadrats	0	5	0	5			0
Number of 0.25-m^2 invertebrate removals/quadrat *	1	1	0	1			0
Number of 0.01-m^2 invertebrate removals/quadrat	0	5	0	5			0
Number of survey periods in which this strategy was used	1	8	0	1			0
Minimum size of organisms identified (mm)							
Before November 1975	1	2	1	1			1
From November 1975 on	1	1	1	1			1

*Nyblade removed invertebrates >5mm in diameter and Webber, >3cm.

†Abbreviations for seasons: Sp = spring; S = summer; F = fall, and W = winter.

The two quadrat sizes used were 0.25 m^2 (0.5 m = 1.6 ft on a side) and 0.01 m^2 (10 cm = 3.9 in on a side). The 0.01-m^2 quadrats were subsamples within the 0.25-m^2 quadrats for estimating abundance and biomass of small abundant invertebrates or algae and within-quadrat variability.

When using the stratified random approach in intertidal rocky habitats, both investigators routinely examined three (upper, mid, and lower elevation) assemblages (zones). The elevations sampled varied somewhat in all zones among investigators and geographic regions, as shown in Table 3. However, this degree of variation is probably insignificant relative to the expected variation in elevation of the zones from the entrance of the Strait of Juan de Fuca to the western reaches of Puget Sound as a consequence of differences in tidal flux and exposure to wave action. Thus, we assumed that these differences posed no significant problems to comparative analyses of the data among sites.

TABLE 3. ELEVATIONS FOR ROCKY INTERTIDAL STRATIFIED SAMPLING

Site	Low Elevation	Mid Elevation	High Elevation
Fidalgo Head (NPS)	0.0 m (0')	0.6 m (2')	1.5 m (5')
Migley Point (NPS)*	—	—	—
Cantilever Pier (SJI)	-0.3 m(-1')	0.9 m (3')	1.8 m (6')
Point George (SJI)#	—	—	—
Pillar Point (Strait)	0.0 m (0')	0.9 m (3')	1.8 m (6')
Tongue Point (Strait)	0.0 m (0')	0.9 m (3')	1.8 m (6')

*No stratified sampling was done at Migley Point.

#No intertidal sampling was done at Point George.

When using the gradient sampling approach in intertidal rocky habitats, both investigators sampled at 1-ft (0.3-m) increments in elevation along at least two transects extending across the intertidal zone between the supralittoral and subtidal zones. Both established sampling sites from +8 ft to -1 ft in northern Puget Sound, and Nyblade (1979a) sampled from +7 ft to MLLW in the Strait.

The number of replicate 0.25-m^2 quadrats sampled at each sampling level varied from one or two in the gradient sampling to five on occasion in the NPS sampling program (Smith and Webber 1978); the most commonly selected number of replicates was four.

A number of variations in the three basic categories of quadrat sampling occurred within the rocky intertidal data set. Generally these include the following.

Algal cover quadrats: The Washington Department of Ecology guidelines for baseline methodology (revised 17 December 1975) indicate that the first operation conducted during quadrat sampling should be to estimate relative cover by algae (Nyblade 1977, Appendix II). However, percent plant cover was not presented in the WDOE reports or included on the File 100 tapes for either of the northern Puget Sound rock sites. Percent plant cover data are available for most samples from the Strait.

Scrapes for algae and small or encrusting invertebrates: Initially it was expected that the 0.25-m^2 scrapes would provide the data on the algal component of the intertidal rock habitats. The main purpose of the 0.01-m^2 scrapes was to quantify abundance of encrusting invertebrates and small, motile and/or cryptic epifaunal invertebrates. At the outset, the 0.01-m^2 quadrats produced little data on algal assemblages and were not an important part of algal sampling.

However, in the Strait, Nyblade (1978,1979a) encountered a dense turf of articulated coralline algae that required subsampling of the 0.25-m^2 quadrats to reduce laboratory costs. In this assemblage, the 0.01-m^2 quadrats were a major source of data on algal cover and biomass. None of the investigators attempted to quantify biomass of encrusting coralline algae.

Two sequences of scraping were utilized at rocky intertidal sites:

1. Remove all algae within the 0.25-m^2 quadrat, bag, and label. Remove all large invertebrates. Then scrape all remaining algae and small invertebrates from five 0.01-m^2 quadrats randomly placed within the larger quadrat, bag, and label separately; or
2. Scrape five randomly selected 0.01-m^2 subquadrats clean of algae and invertebrates. Then remove all algae from the remainder of the quadrat, bag, and label.

The first sequence, used by Nyblade at Cantilever Pier and for the first three quarters of sampling at the Strait sites, appears to be redundant. If all the algae were removed from the 0.25-m^2 quadrat first, none should be found in the subquadrats. In practice, any algae scraped up with the small invertebrates were combined with the algae from the 0.25-m^2 scrape for purposes of data analysis.

Smith and Webber (1978) used the second sequence at Fidalgo Head but combined all algae from all scrapes in a given quadrat during sample processing. Nyblade also used the second sequence starting in the winter of 1977 in the Strait but kept the subsamples separate throughout the analysis. The 1977-78 Strait data therefore allow for the examination of small-scale variability (patchiness) in algal distribution. The subquadrat data are important in these Nyblade samples, in addition, because only large (> 1 cm^2) algae removed from the remainder of the quadrat were identified and weighed.

Removal of larger invertebrates: Larger, motile invertebrates such as chitons and starfish were removed from the 0.25-m^2 quadrat to obtain estimates of their density and biomass. Nyblade's criterion for "larger" was 5 mm while for Smith and Webber (1978) it was 3 cm. The removal of the larger invertebrates occurred before the 0.01-m^2 subquadrat scrapes for all samples except those taken in the Strait in 1977-78 when subsampling was done in the field before anything else in the sampling sequence.

Intertidal Soft Substrates:

Long-term studies were conducted on intertidal soft substrates at 10 sites in northern Puget Sound, six in the Strait of Juan de Fuca and two on the western side of Whidbey Island. The North Puget Sound sites were at Eagle Cove, Deadman Bay, Webb Camp, and Westcott Bay on San Juan Island and the NPS sites Birch Bay, Guemes Island (south end), Fidalgo Bay, Drayton Harbor, Legoe Bay, and Padilla Bay. The sites on Whidbey were at West Beach and Ebey's Landing. The sites in the Strait were at Dungeness Spit, Beckett Point, North Beach (sand), Jamestown, Twin Rivers, and Kydaka Beach, on the Olympic Peninsula. (Figure 1 and Table 1.)

The sampling techniques used on intertidal soft substrates, detailed in Table 4, basically fall within a single category of infaunal sampling, namely, collection of "core" samples. Two sizes of "core" samples were collected and sieved differently to obtain estimates of the density of larger and smaller animals living in the sediment. The two sizes of "core" samples collected were 0.25 m^2 x 30 cm (75 l = 2.6 ft^3) and 0.05 m^2 x 15 cm (7.5 l).

When using the stratified random approach in intertidal soft substrate habitats, both investigators routinely examined three (upper, mid and lower) elevations, except that Smith and Webber (1978) examined only two on sand and mud in northern Puget Sound. The low elevation was usually -0.3 m in North Puget Sound and MLLW in the Strait and on Whidbey. The mid elevation was most often 0.9 m and the high 1.8 m. However, both Webber and Nyblade chose other elevations at some NPS, SJI, and Strait sites, as shown in Table 5. As in the rocky intertidal, this degree of variation is probably insignificant in the upper and mid zones. However, the differences may be significant in the lower zones, where sampling elevations ranged from -0.3 m to +0.5 m.

When using the gradient sampling approach on intertidal soft substrates, Nyblade (1978) sampled at 1-ft increments in elevation from +7 ft to MLLW in the Strait. In northern Puget Sound, Smith and Webber (1978) sampled at 8 equidistant points along the transects on gravel substrates and at 15 on sand and mud, while Nyblade (1978) sampled 9 to 14 levels. On Whidbey Island, Webber (1979) sampled at 1-ft increments in elevation from +6 ft to -1 ft on both sand and gravel. As indicated above, transects in gradient sampling extended perpendicularly across the beach.

The number of samples collected in stratified random sampling at each site varied widely among sites, substrates, and surveys, ranging from 0 to 7 large cores and 2 to 10 small. For example, Nyblade (1979b) did not collect large cores. Smith and Webber (1978) generally collected five replicate samples on gravel and seven on sand and mud while Nyblade (1977, 1978)

TABLE 4. SAMPLING METHODS IN SOFT SUBSTRATE INTERTIDAL SURVEYS

	North Puget Sound			Strait		Whidbey Island
	Nyblade 1977	Smith and Webber 1978	Nyblade 1979	Nyblade 1978	Nyblade 1979	Webber 1979
Strategies and Techniques	7/74-9/76	10/74-8/76	8/77, 8/78	Sp 76/W 77	4/77-2/78	Sp 77-W 78
Stratified Random Sampling						
Number of Levels	3	3 or 2*	3	3	3	3
Sampling Seasons	Sp,S,F,W†	Sp,S,F,W	Sp,S,F,W	Sp,S,F,W	Sp,S,F,W	Sp,S,F,W
No. of 0.25-m^2 x 30 cm samples/level‡	2 to 5	5 or 7§	3 to 5	5 or 3#	5 or 2**	5
Condition when sieved	live	live	live	live	live	live
Sieve mesh size	0.125"	0.5"	12.5 mm	12.5mm	12.5 mm	0.5"
0.25-m^2 quadrats photographed	yes	yes	yes	no	no	no
No. of 0.05-m^2 x 15-cm cores/level	2 to 10	5 or 7§	3 to 5	5 or 3#	5 or 2**	5
Condition when sieved	dead	dead	dead	dead	dead	dead
Sieve mesh size	1 mm	1 or 2 mm††	1 mm	1 mm	1 mm	1 mm
No. of surveys in which this strategy was used	12	4	2	4	4	4
Gradient Sampling						
Number of levels and sampling elevations	9 to 14	8 or 15‡‡	--	8; 7',6',5',4',3',2',1',0'	--	8; 6',5',4',3',2',1',0',-1'
Sampling Seasons	S or F	Sp,S,F,W	--	S	--	S,W
No. of 0.25-m^2 x 30-cm samples/level‡	1 or 2	1 on mud,sand; 2 on gravel	--	2	--	3
Condition when sieved	live	live	--	live	--	live
Sieve mesh size	0.125"	0.5"	--	12.5 mm	--	0.5"
No. of 0.05-m^2 x 15-cm cores/level	1 or 2	1 on mud,sand 2 on gravel	--	2	--	3
Condition when sieved	dead	dead	--	dead	--	dead
Sieve mesh size	1 mm	1 or 2 mm††	--	1 mm	--	1 mm
No. of surveys in which this strategy was used	1	6	--	1	--	2

* 3 levels on gravel and 2 on sand and mud.

† Abbreviations for seasons: Sp = spring; S = summer; F = fall; W = winter.

‡ Nyblade looked at all organisms retained; Smith and Webber looked only at clams and callianassid shrimp.

§ 5 replicates on gravel; 7 replicates on sand and mud.

# 5 replicates on gravel and sand; 3 replicates on mud and mud/gravel.

**5 replicates on gravel and sand; 2 replicates split in half on protected sand and mixed sediment.

††2 mm before 11/75; 1 mm after 11/75.

‡‡8 on gravel and 15 on sand and mud.

TABLE 5. ELEVATIONS FOR SOFT SUBSTRATE INTERTIDAL STRATIFIED SAMPLING

Site	Low Elevation	Mid Elevation	High Elevation
Drayton Harbor (NPS)—mud[*]	—	—	—
Fidalgo Bay (NPS)—mud	0.5 m (1.5')	1.2 m (4')[#]	—
Padilla Bay (NPS)—mud[*]	—	—	—
Birch Bay (NPS)—sand	-0.3 m(-1')[+]	0.9 m (3')	—
Guemes South Shore (NPS)—pebble/gravel	-0.3 m(-1')	0.6 m (2')	1.5 m (5')
Legoe Bay (NPS)—pebble/gravel[*]	—	—	—
Westcott Bay (SJI)—mud	-0.3 m(-1')	0.6 m (2')	1.7 m (5.5')
Eagle Cove (SJI)—exposed sand	-0.3 m(-1')	0.9 m (3')	1.8 m (6')
Deadman Bay (SJI)—exposed gravel	-0.3 m(-1')	0.9 m (3')	1.8 m (6')
Webb Camp (SJI)—protected gravel[**]	-0.3 m(-1')	0.6 m (2')	1.8 m (6')
Jamestown (Strait)—sandy mud	0.0 m (0')	0.4 m (1.4')	1.8 m (6')
Kydaka Beach (Strait)—exposed sand	0.0 m (0')	0.9 m (3')	1.8 m (6')
North Beach (Strait)—exposed sand	0.0 m (0')	0.6 m (2')	1.8 m (6')
Dungeness Spit (Strait)—exposed gravel	0.0 m (0')	0.9 m (3')	1.8 m (6')
Twin Rivers (Strait)—exposed gravel	0.0 m (0')	0.9 m (3')	1.8 m (6')
Beckett Point (Strait)—gravel/sand/mud	0.0 m (0')	0.9 m (3')	1.8 m (6')
West Beach (Whidbey)—sand	0.0 m (0')	0.9 m (3')	1.8 m (6')
Ebey's Landing (Whidbey)—gravel	0.0 m (0')	0.9 m (3')	1.8 m (6')

[*] No stratified sampling was done at these sites.

[#] The mid elevation at Fidalgo Bay was given as +3' in Smith and Webber (1978) but as 1.2 m (+4') on the File 100 tapes.

[+] The low elevation at Birch Bay was given as +1' in Smith and Webber (1978) but as -0.3 m (-1') on the File 100 tapes.

[**] Webb Camp was alternatively characterized as "mixed fine" or "gravel/sand/mud."

usually collected five on sand and gravel, but only two or three in mud and mixed mud habitats. Five replicates per stratum were collected on Whidbey.

In the gradient sampling programs, replication was lower, usually only one or two samples per level. However, Webber (1979) collected three samples per level on Whidbey.

Descriptions of the basic "core" sampling techniques used at the soft bottom sites reveal differences among investigators and sites.

0.25-m^2 x 30-cm core samples: These large area and volume samples were collected in order to assess density and biomass of the larger, uncommon, infaunal animals (such as clams, snails, and shrimp). Generally, the samples were removed with a shovel. Smith and Webber (1978) used four 25-cm x 25-cm x 30-cm cores in a line in sand and mud. The samples obtained by shoveling or coring were sieved in the field while the organisms were still alive; hence they were dubbed "live sieves." The mesh size of the sieves used to screen these samples varied from 0.125 inches (3.2 mm; Nyblade 1977) to 12.5 mm (0.5 inch; Smith and Webber 1978, Nyblade 1978 and 1979a, Webber 1979). In the Nyblade studies all animals retained on the sieves were examined whereas Smith and Webber generally looked at only clams and callianassid shrimp.

0.05-m^2 x 15-cm cores: These small area and volume cores were collected in order to assess density and biomass of the smaller, more abundant infaunal organisms. All of these samples were preserved whole by mixing with a formalin-seawater solution and sieved later with a 1-mm or 2-mm sieve as indicated in Table 4.

Intertidal Cobble Substrates:

Long-term studies were conducted on intertidal cobble habitats at six NPS, SJI, Strait, and Whidbey sites. The sites in northern Puget Sound were at South Beach (SJI) and Cherry and Shannon Points (NPS). The Whidbey Island site was at Partridge Point. The Strait sites were at Morse Creek and North Beach (cobble) on the Olympic Peninsula. (Figure 1 and Table 1.)

The sampling techniques used on intertidal cobble habitats basically fall into the three categories of quadrat sampling described for rocky intertidal habitats and a single category of infaunal sampling, namely, collection of "core" samples. Generally, the sampling methods for cobble combined those described above for rock substrates and soft sediments. Three quadrat sizes were used: 0.25 m^2, 0.05 m^2 and 0.01 m^2. The smaller quadrats were subsamples within the 0.25-m^2 quadrats for estimating abundance and biomass of small abundant invertebrates or algae. The two core sample sizes used were 0.25 m^2 x 30 cm deep and 0.05 m^2 x 15 cm deep. The specifics of replication, quadrat and sieve sizes, sequence of collection, and sampler placement varied considerably between investigators and surveys. For instance, Nyblade (1977) intentionally selected an impoverished cobble site (South Beach) on San Juan Island that lacked algal cover and abundant invertebrates. He thus did not use quadrat sampling techniques there in contrast to the other cobble sites. The 0.05-m^2 subquadrats were used at NPS sites and the 0.01-m^2 subquadrats at Strait and Whidbey sites.

Because of the great differences in sampling techniques among sites and the obvious differences in the assemblages disclosed, we have decided to treat the cobble methods only generally. The most suitable means of determining details of methods is to refer to the investigators' reports.

Subtidal substrates:

Surveys were conducted on subtidal habitats offshore of the intertidal study areas at 23 sites in northern Puget Sound and the Strait of Juan de Fuca and on Whidbey Island (Table 1). The sites in North Puget Sound were at Point George on Shaw Island; South Beach, Eagle Cove, Deadman Bay, Webb Camp, and Westcott Bay on San Juan Island; and at Birch Bay, Cherry Point, the south side of Guemes Island, Fidalgo Bay, and Fidalgo Head. The sites on Whidbey were West Beach, Partridge Point, and Ebey's Landing. The sites in the Strait were Morse Creek, Dungeness Spit, Twin Rivers, Kydaka and North Beach, Jamestown, and Beckett, Tongue, and Pillar Points.

In addition, Smith (1979) examined subtidal habitats at 19 locations in the northern and southern approaches to, and within, Rosario Strait. Each site was examined one time at three depth levels between July 2 and October 7, 1976. The locations are indicated in Figure 2.

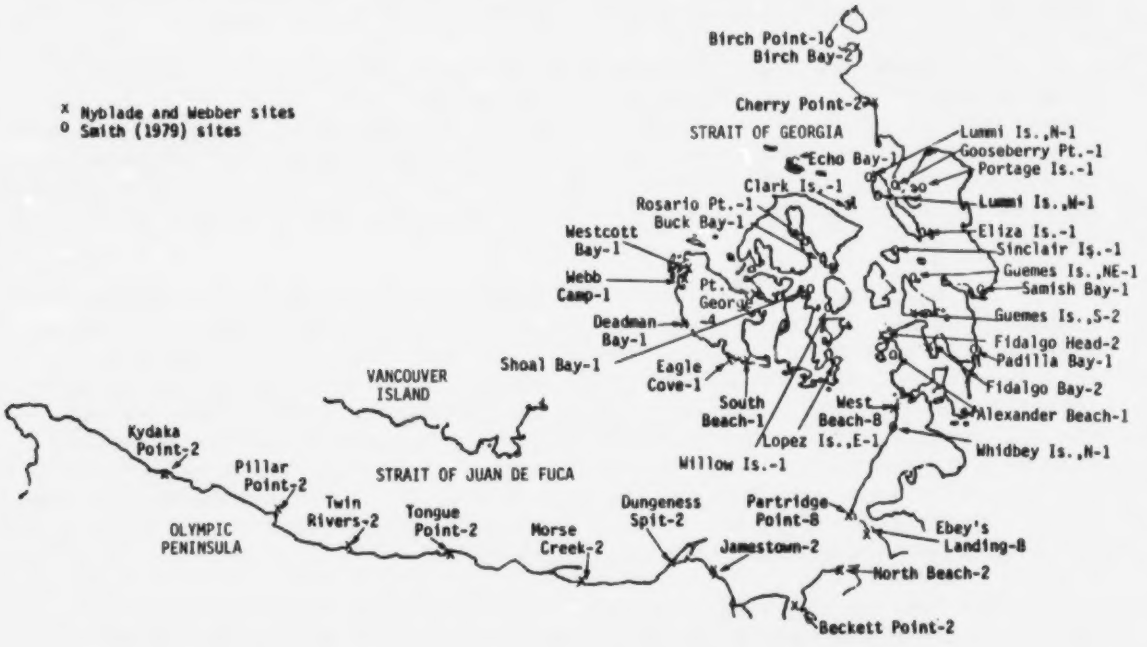
x Nyblade and Webber sites
o Smith (1979) sites
Birch Point-1
Birch Bay-2
Cherry Point-2
STRAIT OF GEORGIA
Echo Bay-1
Lummi Is.,N-1
Gooseberry Pt.-1
Portage Is.-1
Clark Is.-1
Rosario Pt.-1
Buck Bay-1
Lummi Is.,W-1
Westcott Bay-1
Eliza Is.-1
Sinclair Is.-1
Webb Camp-1
Pt. George-4
Guemes Is.,NE-1
Samish Bay-1
Deadman Bay-1
Guemes Is.,S-2
Fidalgo Head-2
Shoal Bay-1
Eagle Cove-1
Padilla Bay-1
Fidalgo Bay-2
VANCOUVER ISLAND
South Beach-1
West Beach-8
Alexander Beach-1
Lopez Is.,E-1
Whidbey Is.,N-1
Kydaka Point-2
Willow Is.-1
Pillar Point-2
STRAIT OF JUAN DE FUCA
Twin Rivers-2
Tongue Point-2
Morse Creek-2
Dungeness Spit-2
Partridge Point-8
Ebey's Landing-8
OLYMPIC PENINSULA
Jamestown-2
North Beach-2
Beckett Point-2

Figure 2. Subtidal sites including those of Smith (1979). Number after site name indicates number of sampling periods for which data are available.

Subtidal surveys were completed only one or two times at most sites. More frequent sampling occurred at Point George and the three Whidbey Island sites. In addition, quarterly subtidal samples were collected during the first year of sampling in the Strait, but only the first quarter samples were completely processed. Second, third, and fourth quarter samples were curated without identifying, counting, or weighing the organisms.

The sampling techniques utilized in the subtidal surveys were distinctly simpler than those employed intertidally but varied widely among investigators, especially on soft substrates. Generally, quadrat techniques were used on rocky substrates. These were augmented with airlift core or grab sampling techniques on unconsolidated substrates such as cobble, gravel, and sand. Core or grab sampling techniques were often the only sampling techniques used on sand and mud substrates. (Table 6). Three sizes of square quadrats--1.0, 0.25 and 0.1 m^2—were used to facilitate efficient estimation of plant and animal density. Four sizes of samples were collected to assess infaunal assemblages in soft substrates. These included two square core samples (0.25 m^2 x 30 cm and 0.05 m^2 x 15 cm) and samples from 0.03-m^2 and 0.1-m^2 van Veen grab samplers. Smith and Webber used airlift cores while Nyblade used the van Veen.

In the MESA studies, the investigators typically sampled at depths of 5 m (16 ft) and 10 m (33 ft), but otherwise sampling depths were not consistent (Table 7). Nyblade (1977) sampled only at -2.5 m on San Juan Island. In the other sampling programs there was generally at least one depth in the 2-m to 5-m range and one in the 7-m to 10-m range.

The number of replicate samples collected was fairly consistent, ranging from two to four regardless of substrate, etc. (Table 6). In all cases, replication was too low for effective assessment of density or biomass of epibenthic or infaunal organisms. In an attempt to increase replication, in the second year of the Strait study, Nyblade (1979a) split in half each of the two van Veen samples collected at each station, thus producing four samples.

The basic "core" sampling techniques used in the subtidal studies are similar to those described above for intertidal soft substrates. The major departure is that Nyblade used a 0.03-m^2 van Veen grab sampler for his shallow subtidal SJI samples and a 0.1-m^2 van Veen in the Strait to collect infaunal samples. In addition, Webber collected his infaunal samples with the aid of an airlift sampler, which sucked up the sediments and deposited them in a 0.7-mm mesh bag for sieving. Smith (1979) also used an airlift, but he used a 1-mm mesh bag and, for final sieving in the laboratory, a 2-mm sieve. Sieve sizes used for final sieving were consistently 1 mm for subtidal samples collected by Nyblade and Webber.

The quadrat sampling techniques were similarly very like those described above for intertidal rock substrates. However, Smith (1979) employed replicated 1.0-m^2 quadrats to measure the density of animals with dimensions > 10 cm. As in the case of the infaunal samples, collection of animals and plants in scraped quadrats was facilitated by use of an airlift sampler in the NPS, Whidbey, and Smith (1979) studies.

TABLE 6. SAMPLING METHODS IN SUBTIDAL SURVEYS

Techniques	San Juan Island- Point George Nyblade 1977	Strait of Juan de Fuca Nyblade 1978 Sp/76-W/77*	Strait of Juan de Fuca Nyblade 1979a Sp/77-W/78	Whidbey Island Webber 1979 Sp/77-W/79	N. Puget Sound Rosario Strait Smith 1979 7/76-10/76	N. Puget Sound Rosario Strait Webber File 100 Date Tapes
Number of Levels	3	2§§	2	3	3	6
Substrates						
Rock	X	X	X		X	
Cobble (mixed coarse)		X	X		X	X
Gravel (mixed fine)		X	X	X	X	X
Sand	X	X	X	X	X	X
Mud	X	X	X		X	X
Sampling Season	F,W,Sp,S	S	S	Sp,S,F,W	S	Sp,F
Rocky Substrate (rock, cobble, and gravel)				None		None
Number of 1.0-m^2 quadrats for large invertebrates/level					3†	
Number of 0.25-m^2 algal scrapes/level	2	4	4		3	
Number of 0.01-m^2 algal scrapes/0.25-m^2 quadrats	1					
Number of 0.25-m^2 small invertebrate removals/level	2‡	4	4		3§	
Number of 0.01-m^2 removals/quadrat	1#					
Soft Substrates (cobble, gravel, sand, and mud)	None					
Number of 0.25-m^2 x 30-cm core samples/level				3**		
Number of 0.05-m^2 x 15-cm core samples/level				3#	3#	2
Number of 0.1-m^2 van Veen grab samples/level		2-3#	2#,††			
Number of 0.03-m^2 van Veen grab samples/level	2					
Number of 0.05-m^2 invertebrate scrapes/level						2#,‡‡
Number of 0.25-m^2 algal scrapes/level						2#

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* Sp = spring, S = summer, F = fall, W = winter

† >5 cm dimension

‡ >10 cm dimension

§ 3< x <10 cm dimension

Sieved through a 1-mm sieve

**Sieved through 12.5-mm sieve

††Each grab sample was halved to increase replication

‡‡Not used at Fidalgo Bay

§§Samples were collected at two additional levels in summer 1976 and processed for long-term storage but not analyzed.

TABLE 7. GENERAL SUBSTRATE CLASSIFICATION AT SUBTIDAL STATIONS BY DATE AND DEPTH

Site/Date		Depth (m)										
		-1.5	-2.0	-2.5	-4.0	-5.0	-6.0	-7.5	-8.0	-10.0	-12.0	-15.0
						North Puget Sound[*]						
Birch Bay	760303		S[†]		S		M		M	M	M	
Cherry Point	760316		MC		MF		MF		MF	MF	MF	
Fidalgo Bay	760319 760917		M		M		M		M	M	M	
Fidalgo Head	760320		MC		MC		MC		MC	MC	MC	
Guemes Island	760220		MC		MC		MC		MC	MC	MC	
						San Juan Islands[‡]						
Deadman Bay	741016			S								
Eagle Cove	741016			S								
Point George	741127					R				R		R
	750206					R				R		R
	750311					R				R		R
	750501					R				R		R
South Beach	741016			S								
Webb Camp	741016			M								
Westcott Bay	741016			M								

(continued)

TABLE 7. (continued)

Site/Date		Depth (m)										
		-1.5	-2.0	-2.5	-4.0	-5.0	-6.0	-7.5	-8.0	-10.0	-12.0	-15.0
						Whidbey Island§						
Ebey's Landing	770428	MC				MF				MF		
	770822	MC		MF		MF		MF		MF		
	771118	MF				MF				MF		
	780213	MC		MF		MF		MC		MC		
	780508	MC				MF				MF		
	780630	MC		MF		MF		MF		MF		
	781012	MC				S				MF		
	790118	MF		S		MF		MF		MF		
Partridge Point	770430	MC				MF				MF		
	770822	MC				MF				MF		
	771108	MF				MF				MF		
	780206	MC		MC		MF		MC		MC		
	780516	MC				MF				MF		
	780710	MF		MC		MF		MF		MF		
	781013	MF				MF				MF		
	790122	MC		MC		MF		MF		MF		
West Beach	770419	S				S				S		
	770810	MC		S		S		S		S		
	771103	S				S				S		
	780124	S		S		S		S		S		
	780418	S				S				S		
	780629	S		S		S		S		S		
	781014	S				S				S		
	790121	S		S		S		S		S		

(continued)

TABLE 7. (continued)

Site/Date		Depth (m)										
		-1.5	-2.0	-2.5	-4.0	-5.0	-6.0	-7.5	-8.0	-10.0	-12.0	-15.0
Strait of Juan de Fuca#												
Beckett Point	760602					S				S		
	770606					S				S		
Dungeness Spit	760602					MF				MF		
	770607					MF				MF		
Jamestown	760602					S				S		
	770607					S				S		
Kydaka Beach	760603					S				S		
	770621					S				S		
Morse Creek	760603					MC				MC		
	770607					MF				MC		
North Beach	760602					S				MF		
	770624					S				MF		
Pillar Point	760603					S				S		
	760622					S				S		
Tongue Point	760702					R				R		
	760703					R				R		
	770506					R				R		
	770617					R				R		
Twin Rivers	760614					MF				S		
	770622					MF				--		

(continued)

TABLE 7. (continued)

Site/Date		Upper		Middle		Lower	
		Depth (m)	Sediment	Depth (m)	Sediment	Depth (m)	Sediment
				Approaches to Rosario Strait**			
Alexander Beach	760716	2.1	S	9.1	S	15.2	S
Buck Bay	760818	2.7	MC	6.7	MF	13.1	M
Birch Point	760922	4.3	MC	8.5	S	14.6	S
Clark Island	761005	3.4	M	7.0	MC	13.7	MC
Echo Bay	761001	3.0	M	8.5	M	15.2	M
Eliza Island	760915	3.0	MF	8.2	M	15.2	M
Guemes Island, NE	760702	3.7	S	7.6	MC	16.8	MC
Gooseberry Point	760803	3.0	S	7.6	M	13.7	M
Lopez Island, E	761007	3.7	MF	9.1	S	14.6	MC
Lummi Island, N	760825	4.6	S	9.8	MF	15.8	MF
Lummi Island, W	760909	3.7	MF	7.6	MF	13.1	MF
Padilla Bay	760924	2.4	S	7.0	M	14.6	M
Portage Island	760813	4.6	S	8.2	M	13.7	M
Rosario Point	760721	3.0	R	8.5	R	16.8	R
Samish Bay	760915	4.0	M	9.1	M	15.2	M
Shoal Bay	760728	4.3	MC	8.5	MF	12.2	M
Sinclair Island, N	760730	3.7	S	7.6	MF	16.8	MC
Willow Island	760811	4.6	R	9.8	R	14.3	R
Whidbey Island, N	760920	3.0	S	9.8	M	15.2	M

* Webber, personal communication.

† Abbreviations for substrate types: M = mud, S = sand, MF = mixed fine, MC = mixed coarse, R = rock.

‡ Nyblade 1977 and personal communication.

§ Webber 1979 and File 100 data tapes.

Nyblade 1978, 1979.

**Smith 1979.

4.2 PROBLEMS ENCOUNTERED

4.2.1 From Field Methodology

Levels of replication:

As noted in Section 4.1, the number of replicate samples collected at a given site, date, and elevation varied greatly with habitat type, investigator, and time. The level of replication and inconsistency in numbers of replicates have two important consequences.

First and most important, the usual level of replication (between two and five replicates per site/date/elevation) is too low to provide an adequate description of the real variability in abundance and biomass for the animal and plant populations examined. For most of the density and biomass estimates, the range of variation within one standard deviation of the estimated mean includes zero. Calculations in Section 6 suggest that considerably greater replication is required to provide adequate estimates of population parameters for even the most common species.

Next, assemblage parameters (e.g., numbers of species or individuals and species diversity) can be compared on the basis of quadrat averages or total (pooled) sampling effort. Because all of these parameters increase unpredictably with an increasing number of samples, they should not generally be compared for pooled data if replicate number varies among the sites compared. Therefore, in our analyses, it was necessary to compare assemblage parameters using estimates of the mean for individual samples rather than for, say, all samples from a given site/date/elevation.

Criteria for large invertebrates:

As noted in Section 4.1, varying size criteria were used for large invertebrate removals in the field. Different sieve sizes and criteria for species to be examined were used for live sieve cores as well.

Estimates of densities and number of species for the large invertebrates would be expected to be somewhat lower and more variable in the Smith and Webber (1978) data, where only those animals over 3 cm in size were removed from the 0.25-m^2 quadrats, than in the other data sets where 5 mm was the criterion. Similarly, larger estimates computed from live sieve data would be expected in the Nyblade WDOE data where a smaller mesh was used, although Nyblade notes that in actuality the species found in these samples were not in the 3.2 mm to 12.5 mm range. Smaller estimates of number of species would be expected from the Webber data where only selected species were considered and the larger sieve size was used.

Sequence used in subsampling:

As described in Section 4.1, the sampling methodology for rock and cobble data involved removing algae and large invertebrates from a 0.25-m^2 area and scraping algae and small invertebrates from subsamples within that area. The order in which these procedures were carried out varied with time and site during the course of the studies, thus complicating the normalization to counts or weights per 0.25 m^2 (Nyblade 1979a, p. 14).

Sampling area and volume:

As with variations in levels of replication, inconsistencies in areas or volumes sampled generally invalidate comparisons of population and assemblage parameters since these parameters do not increase linearly with area or volume. Such inconsistencies are an especially serious problem in the subtidal data since Nyblade, Smith, and Webber used different gear and sampled different areas and volumes (Section 4.1.2).

4.2.2 From sample processing

Missing data from the 1-mm sieve component of the intertidal samples:

Before November 1975, Smith and Webber (1978) sieved the 0.01-m^2 subsamples from rock sites, the 0.05-m^2 subsamples from cobble sites, and the 0.05-m^2 x 15-cm cores from cobble and soft substrates through a 2-mm and 1-mm sieve series. Although the 1-mm material was stored, only the 2-mm fraction was identified, counted, and weighed. After November 1975, both fractions were fully processed.

Although the preserved 1-mm sieve data were processed later for some of the sites, they were not processed for Migley Point (rock), Shannon Point (cobble), and the soft bottom sites at Drayton Harbor, Legoe Bay, and Padilla Bay. These sites were discussed and compared with the other northern Puget Sound sites by Smith and Webber (1978). They were not sampled after November 1975, so only data for the 2-mm fraction are available for them. Because data for the 2-mm fraction would produce smaller estimates of numbers of individuals and species than 1-mm data and because 1-mm sieving was done at all other intertidal sites in both the WDOE and NOAA/MESA studies, we have not included the sites with only 2-mm fraction data in our analyses.

Partitioning of samples in soft bottom intertidal and subtidal data:

According to Nyblade (1979a, p. 10):

> "In an effort to increase replicate number and hopefully to decrease sample variance at Beckett Point, Jamestown, and all soft bottom subtidal sites, the first year quadrat size was halved in the second year by sample partitioning. Instead of three replicates, four half size replicates were taken."

Indeed, this procedure may have decreased sample variance in the data set, but it had no effect on sample variance in the ecosystem. Because we would not expect the split halves to be comparable to full-sized independent replicates in terms of real sampling variability, we recombined the halves into a single replicate before analysis to ensure comparability with samples taken at other sites and times.

4.2.3 From data processing

Because the data base analyzed in this study is so large (approximately 107,300 80-character records) statistical analyses of the data would be impossible without the aid of computers. Therefore, the data had to be available in machine-readable form. The form chosen by NOAA/MESA was the National Oceanographic Data Center (NODC) intertidal/subtidal File Type 100 format magnetic tapes (NOAA 1976). Most problems we encountered in data processing resulted from discrepancies and errors in coding these File 100 tapes.

Combining samples for intertidal rock and cobble data:

Data obtained by each collection method from each quadrat at intertidal rock and cobble sites were rescaled and combined to give a single count and weight per 0.25 m^2 for each species found in the quadrat in some cases. This combining, which took place before the data were put on tape, was done for all samples collected between 1974 and 1978 at Cantilever Pier (SJI) and for 1976 samples from rock and cobble sites in the Strait. It is impossible to determine which species were collected by which method or assess subsampling variability from the combined samples. Uncombined data for all sites are available from Nyblade, but not in File 100 format.

At Fidalgo Head, partial combining of the data was done. Data from the five 0.01-m^2 subsamples were added to obtain a number per 0.05 m^2.

Because only combined data were available at some sites and times, we combined data from the others to enable cross-site and year-to-year comparisons. In the cases, discussed above, where the properly normalized counts and weights for species obtained by more than one method could not simply be added because of the order in which collection methods were applied, we chose the count and weight corresponding to the method that gave the largest value of count or weight.

Data not yet available in NODC File 100 format:

We noted earlier that 1-mm fractions for several NPS sites and some subtidal Strait data have not been processed. These data therefore do not exist in File 100 format. In addition, some data that have been processed and reported by the investigators who collected them have not been archived on File 100 tapes. Hence, they are not readily available to other investigators wishing to perform statistical analyses.

The major data sets that fall into this latter category are the northern Puget Sound subtidal study reported by Smith (1979) and the intertidal data of Nyblade (1979b).

Each of the 19 subtidal sites discussed by Smith was sampled only once during summer or fall of 1976. The field and laboratory methodology used differed from that of the subtidal sampling programs from which other File 100 data are available. For example, subtidal depth strata were defined differently at each site instead of using the same depths at all sites. A 1-mm mesh size bag was used for collection and a 2-mm sieve was used in the laboratory. Hence, the Smith data, even if available on tape, could not easily be compared with other data.

The lack of File 100 tapes of the Nyblade (1979b) data is more serious. These data were taken in August 1977 at Cantilever Pier, Deadman Bay, Eagle Cove, and Westcott Bay and during the summer of 1978 at these same San Juan Island sites and four other northern Puget Sound sites (Cherry Point, Guemes Island, Birch Bay, and Fidalgo Bay). Hence, they represent more recent samples than those on tape and, in addition, the only sites sampled independently by both Nyblade and Webber.

Subsets of other data sets collected during the WDOE and NOAA/MESA studies are also missing from the tapes. For example, no live sieve samples are included in the northern Puget Sound data taken before 1977 except for those from Webb Camp and Westcott Bay in the summers of 1975 and 1976 and the fall of 1975. Other such omissions are documented in interim reports (Zeh 1980a,b,c,d,e) submitted to NOAA/MESA in the course of the present study.

Finally, data collected by Nyblade and Webber for WDOE during the summers of 1979 and 1980 at selected baseline sites have not been archived on File 100 tapes.

Errors and inconsistencies in tapes:

Incorrect as well as missing data presented serious problems during the present study. Errors found in the data, many of which have been or are being corrected, have been discussed by Zeh (1980a,b,c,d,e). We wish to highlight here a few of the most serious problems and ways they could be avoided in future sampling programs.

Many of the worst problems in the data stemmed from the fact that the File 100 tapes were made several years after most of the data were collected. Future sampling programs could avoid these problems by requiring timely submission of data tapes by investigators. The tapes should be checked using programs such as those being developed by Mike Crane of NOAA's Environmental Data and Information Service (EDIS). Errors detected in taxonomic codes, gear codes, etc., could then be corrected before the passage of time and shifts in responsible personnel make the task difficult if not impossible.

It should also be required that investigators involved in sampling programs submit listings of "raw" data, for example, those included as Appendix I in Nyblade (1978). Such listings were not available for the data reported by Smith and Webber (1978), and consequently detection and correction of bad data on their File 100 tapes was extremely difficult.

Two aspects of the present File 100 specifications led to serious problems in the data tapes. EDIS is presently modifying File 100 specifications to alleviate these problems.

The first source of problems was the definition of the Sample Number that appears in Record Types 3, 4, 5, and 6 as a "Unique quadrat or haul number." The problems stemmed from the fact that several different sampling methodologies, represented by distinct gear codes, were often used in the same quadrat. The gear code appears on Record Type 3 (Biological Sample Description), but not Record Type 4 (Species Identification). Therefore, in many cases it was impossible to determine which gear (and therefore what area or volume of substrate) had yielded a particular species and its associated count and weight. In these cases, the data could not be correctly normalized to count or weight per some specified sample area or volume.

The Sample Number in File 100 specifications should be redefined so that one or two digits specify the "Unique quadrat" within "Unique cruise number or date" and "Station Number," which are also given on Record Types 3, 4, 5, and 6. The remaining digit or digits of the Sample Number should allow each Type 4, 5, and 6 record to be unambiguously matched with the appropriate Type 3 record and hence the correct Sample Description information such as gear code. Subsamples within a quadrat should each have their own Type 3 record. A sample numbering scheme of this sort was used for some of the Strait data.

A second weakness of the existing File 100 specifications stems from an attempt to provide flexibility in data arrangement. The specifications require that all records at a given station follow the Station Header record. The other records may appear in any order as long as they have ascending sequence numbers. Most of the baseline data was arranged with each Sample Description record preceding the associated group of Species Identification records. This arrangement proved to be the most convenient for purposes of data analysis. We recommend that File 100 specifications require, rather than suggest, such an arrangement. The Strait data, which also met the existing specifications, were arranged with all Sample Description records in a block followed by all Species Identification records. This arrangement was less convenient and more error-prone. It should be ruled out in future File 100 data sets.

Inadequate data on habitat characteristics:

We had hoped to use the File 100 Habitat Code and Sediment Size Analysis records in defining quantitative models for the data, but data inadequacies precluded this approach.

The Habitat Code, part of the Sample Description record, consists of three digits. The first characterizes wave energy/beach gradient; the second, sediment size; and the third, surface organics (for example, shell fragments or eelgrass). It thus contains a great deal of information critical to modelling the soft-bottom habitats. However, the Habitat Code was missing from the SJI data. It was included in the other data sets but in many cases did not correspond well to descriptive information provided in reports or to the Sediment Size Analysis data.

For example, the Habitat Code for all intertidal Sample Description records from West Beach and Ebey's Landing in the Webber MESA data indicated moderate wave energy and moderate beach gradient, coarse sand, and no surface organics. However, sediment size data indicate that both sites consisted of a gravel-sand mix. Large gravel (pebble) usually predominated at Ebey's Landing whereas the composition at West Beach varied with time and elevation from 18 percent sand with the remainder gravel to 99 percent sand. Webber (1979) also indicated that the beach slope at West Beach changed dramatically during the course of the study but was always within the File 100 definition of low beach gradient (slope less than 15 percent).

The Habitat Code on Sample Description records should reflect observed changes in sediment composition and beach slope if it is to be useful for modelling. NODC may wish to consider refinements to the definition of this code to make it more sensitive to habitat differences. However, if the present code is used correctly by investigators it is probably adequate.

Sediment size analyses in the existing Puget Sound data set are inadequate. No analyses were available for the NPS data. Sediment Size Analysis records from each sampling period were included in the Whidbey data, but there was only one replicate at each time and elevation. Thus it is impossible to assess which apparent changes in sediment composition through time were real and which were merely the result of sampling variability.

Sediment Size Analysis records were included in both the SJI and Strait data. There were two replicates per elevation in most cases so sampling variability could be assessed. However, sediment size analyses were included for only one or two dates at each site, so temporal changes could not be assessed.

4.2.4 From taxonomy

In any long-term sampling program, some problems in taxonomy are inevitable. Species incorrectly identified in early samples may be correctly identified later. However, this data set has several more systematic problems in taxonomy that need to be pointed out.

Inconsistencies in level of identification:

Particularly in the WDOE data, some plants and animals were identified to different levels by the different investigators at different times. For example, amphipods were identified to genus or species by Nyblade for the most part only in the first year of the study and by Smith and Webber only in the second. In general, it appeared that Nyblade identified the species as well as genus of organisms more often than Smith and Webber. Discrepancies of this type make comparisons of such numerical assemblage parameters as species richness and diversity across sites and times very difficult.

Incorrect taxonomic codes:

Even when organisms were identified to species level, data were often not available on tape because incorrect taxonomic codes were used. The NPS data contained numerous codes that could not be unambiguously translated to the NODC codes specified for File 100. The SJI and Strait data contained codes corresponding to species identified by Nyblade for which NODC codes were unavailable. For these species he used the NODC genus code and his own code for the species digits.

SECTION 5

GENERAL APPROACH TO OBJECTIVE 1

To attain the objectives of providing a statistical basis for assessing future changes in community structure at any site in the study area and of assessing the relative contributions to variability of factors such as elevation, site, year, and season, it was necessary to look at data across sites and times. Detailed descriptions of communities found at most of the particular sites and times sampled have been given by the investigators who collected the data and are, for the most part, outside the scope of the present study.

Our general approach to the data base was to look for common rather than unique characteristics of different sites and times. In addition, we generally restricted our analyses to data available on File 100 tapes so that other investigators using the tapes could verify or augment our results.

5.1 OUR METHODS OF RESOLVING PROBLEMS

In Section 4, we mentioned solutions to some problems encountered. The common denominator of these solutions was the desire to ensure that different subsets of the data could be meaningfully compared. Our approach to taxonomic problems also was designed to eliminate systematic differences that were due to the investigators rather than the samples.

The first step in analysis of data from each of the four major habitat types defined in Section 4 was to extract all the data that we wished to consider. Necessary data from File 100 Sample Description and Species Identification records were combined to form records containing station and sample numbers, date, elevation, gear code and quadrat area, percent plant cover if available, and information on weight method and subsample percent as well as taxonomic code, count, and wet weight for a plant or animal.

All taxa found in the habitat with number of samples at each site, date, and elevation stratum were listed. The listings were examined to determine invalid taxonomic codes, taxa that should be combined to eliminate differences in level of identification among different sites and dates, and key taxa to be used in clustering and other statistical analyses.

Key taxa were selected on the basis of such factors as ease of identification of an organism, frequency of occurrence, and biological importance as well as data-dependent considerations. Our general "lumping rules" are given in Appendix B, which also contains the "dictionaries" created to associate taxonomic codes found on the File 100 tapes with those to be used in analyses.

Statistical analysis began after the dictionaries of Appendix B were used to correct taxonomic codes and other programs were run to correct bad gear codes, combine samples as needed, and resolve other errors and inconsistencies.

5.2 SUMMARY OF STATISTICAL ANALYSES

5.2.1 Population parameters and assemblage parameters

The goal of this study was to predict population parameters such as number of individuals for animal species and biomass for plants. However, the patchy and variable distributions of most organisms make prediction difficult. The reports of Nyblade and Webber cited in previous sections offer numerous examples.

The distribution of a species generally cannot be modelled well by the usual probability distributions and, therefore, statistical methods based on these distributions do not apply. In Appendix A, which contains detailed descriptions of our statistical methodology, we discuss this problem and approaches that alleviate it in some cases. No statistical manipulations can be expected to yield predictability of counts and weights for rare or extremely variable organisms. Therefore, we attempted to model population parameters for only the most ubiquitous species in each habitat.

We also considered numerical assemblage parameters that characterize the entire community in a given habitat:

S_a = number of animal taxa identified in a sample,

S_p = number of plant taxa in a sample,

N_a = total count of animals in a sample,

W_p = total plant biomass (wet weight) in a sample,

H'_a = Shannon-Weaver diversity for animals (Pielou 1966)

$$= -\sum_{i=1}^{S_a} \frac{N_i}{N_a} \ln \frac{N_i}{N_a}$$

where N_i is the number of animals in the ith taxonomic group in the sample, and

H'_p = plant biomass diversity

$$= - \sum_{i=1}^{S_p} \frac{W_i}{W_p} \ln \frac{W_i}{W_p}$$

where W_i is the weight of the ith plant taxon. Animal biomass W_a and animal biomass diversity H'_b, defined analogously to W_p and H'_p, and percent plant cover were considered for those subsets of the data in which they were available.

Our definitions of assemblage parameters are conditioned by some of the limitations of the data set discussed in Section 4. We have already noted that percent plant cover was not included in the WDOE data sets. Animal weights were not consistently available in any of Nyblade's data sets because the baseline methodology called for weighing only those species whose individuals' aggregate weight exceeded 0.1 g. For both plants and animals wet weights were used rather than dry weights. The latter were generally unavailable because the sampling program mandated preservation of samples for future reexamination if needed.

Animal and plant parameters were computed separately to provide a more precise characterization of habitats and to avoid mixing count and weight data.

It is important to note that our numerical assemblage parameters were computed for each replicate rather than from pooled data including all replicates at a given site, date, and elevation or from even larger groups of samples. When such parameters were discussed in the reports of Smith, Webber, and Nyblade, they were generally computed from pooled data. Hence, larger numbers of taxa and diversities than those given in this report were obtained.

We had two reasons for computing assemblage parameters on a sample-by-sample basis. First, because these parameters increase unpredictably with increasing number of samples, they cannot be compared if they are computed from pools including different numbers of replicates. Since level of replication varied widely in the data base, single-replicate computations were required if different sites and times were to be compared. In addition, we needed separate estimates for each replicate to assess sampling variability in the parameters.

There are several motivations for concentrating on the modelling of assemblage parameters instead of parameters for particular populations. The first and most obvious is that the numerical assemblage parameters reduce the often lengthy list of taxa with their counts and/or weights found in each sample to a few simple summary statistics that at least partially characterize the sample. A second reason for looking at assemblage parameters is that there is a statistical basis (see Appendix A) for hoping that the distributions of such parameters will come closer to distributions such as the normal assumed by standard statistical methodology than those of individual population parameters.

5.2.2 Cluster analysis to describe assemblages

The numerical assemblage parameters discussed above, while providing a concise characterization of assemblages, have the drawback that two samples with no species in common could produce identical assemblage parameter values. Cluster analysis, in contrast, produces a summary characterization of a group of samples which takes into account the degree of similarity in presence and (optionally) abundance of species found in those samples.

Cluster analysis is a technique for dividing a set of entities into non-overlapping subsets. These subsets are defined by the requirement that elements of a given subset are more "similar" to one another than they are to elements of any other subset. In the normal (Q-mode) analyses of the present study, the entities being classified were samples, and the attributes being used to determine levels of similarity were counts of species found in the samples. For more details concerning definitions of "similarity" and other aspects of the cluster analysis methodology used in the present study, refer to Appendix A.

Cluster analysis results were displayed graphically in dendrograms that showed how small clusters of similar samples were nested within larger less similar groups. Cluster analysis is primarily a descriptive technique, suggesting categories and factors that can be explored quantitatively via other statistical analyses.

5.2.3 Analyses of population and assemblage parameters

Multiple regression and analysis of variance techniques were used for determining variability due to annual, seasonal, and tidal elevation effects and site differences as well as residual sampling variability. The general procedure was to select subsets of the data within which the techniques could appropriately be applied to population and assemblage parameters. Because of the inadequacies in data characterizing habitats, we had to rely on cluster analyses, descriptive information in reports, and our own experience with the sites in constructing predictive models.

Regression analysis was used on subsets of data from single sites because cluster analyses made it obvious that no simple available variables could adequately represent site effects. Independent variables representing elevation and date in our multiple regression models, described in detail in Appendix A, allowed assessing the contributions of elevation, season, and year effects to the overall variability in the dependent variables. Dependent variables considered were the numerical assemblage parameters S_a, S_p, H'_a, H'_b, H'_p, and percent plant cover and logarithms of N_a, W_a, and W_p. The log transformation and its motivation are discussed in Appendix A.

Regression analysis is ideally suited to assessing variability contributed by factors that can take on many values over some range. Analysis of variance is more useful when dealing with factors that have a relatively small number of discrete levels; each group in the analysis of variance is associated with a particular level of each of the factors being considered. For example, to assess elevation effects, regression analysis was probably the best technique for data obtained by gradient sampling, while analysis of variance was more appropriate for stratified sampling.

Analysis of variance could be applied to data from several sites because separate sites could define separate groups in the analysis. Both population and assemblage parameters were used in this analysis after a log transformation of counts and weights. Analysis of variance contributes in two ways to providing more definitive results concerning these parameters than the annual or seasonal means at each site and elevation reported, for example, by Nyblade (1977) and Smith and Webber (1978).

The first involves partitioning the variability. If an annual mean is computed instead of a mean on a particular date, the variance of samples about the annual mean will generally be larger than the variance on any particular date. The added variance is due to season effects that cause mean values on different dates to differ. Analysis of variance provides a systematic breakdown of the variance into (1) that attributable to factors such as season represented by the groups in the analysis and (2) the residual (replicate, within-group, or sampling) variability that remains when all factors have been accounted for. If the sampling variability is the same in all groups, analysis of variance also provides a better estimate of its value than the variances calculated for the individual groups.

Second, analysis of variance provides systematic ways of comparing the means of several groups. Statistical tests with specified levels of significance (see Appendix A) for differences among the means can be made.

Different analysis of variance models (one-way, two-way, and nested) were used on different subsets of the data set in this study. All are explained in detail in Appendix A, where we also discuss contrasts (comparisons) between groups that were used extensively in the context of the one-way analysis of variance model.

5.2.4 Predictive models

From the analyses described above, we concluded that the analysis of variance approach yielded the most fruitful predictive models that could be supported by the present data base. This approach uses the mean value of a parameter computed from the most recent available samples at a given site, season, and elevation as the predicted value for the mean of future samples at that site, season, and elevation. (Cross-site prediction will be discussed in a later section.)

If new samples were taken at the site, season, and elevation, the usual test for whether the new mean was different would be a two-sample *t*-test. Alternatively, if the estimate of sampling variability obtained from analysis of variance was considered valid for both the old and new samples, it could be used as the known variance for the slightly simpler normal theory *z*-test. For an example, refer to Dixon and Massey (1969), pp. 114–116. If, as is more likely, the assumptions of the *t*-test (i.e., that both samples came from normal distributions with the same variance) were suspect, we could choose a nonparametric alternative such as the two-sample Mann-Whitney test described in Appendix A.

Verification of our predictive models in the next section employs both the two-sample *t*- and Mann-Whitney tests. Samples from File 100 tapes used in the model-building stage of the analysis were compared with samples from Nyblade (1979b), which are not on tape, for purposes of verification. Power of the tests to detect changes of various magnitudes in population and numerical assemblage parameters is also discussed. The power results provide guidelines for determining the number of replicate samples that should be collected in future sampling programs.

SECTION 6

RESULTS OF OBJECTIVE 1 ANALYSES

6.1 INTERTIDAL ROCKY SUBSTRATES

Of the four rocky intertidal sites included in Objective 1 analyses, Cantilever Pier (SJI) and Tongue Point (Strait) are relatively smooth solid rock. The Pillar Point Strait site is also solid rock, but not smooth. Fidalgo Head (NPS) is variable, with some smooth rock shelves and some broken areas where the rock surfaces consist of boulders. Cantilever Pier is the least exposed of the sites and Pillar Point the most exposed.

Site locations are shown in Figure 1 of Section 1. Sampling dates and type of sampling (gradient or stratified) are given in Table 1 of Section 4. Samples from all tabled dates were available on File 100 tapes for analysis, and 933 different plant and animal taxa were identified in these samples.

Brief explanations of statistical techniques and terminology used in the analyses of this and subsequent sections are given in Section 5. Details can be found in Appendix A.

6.1.1 Community analyses

Data from the rock sites were subjected to cluster analysis to illustrate similarity patterns among stations (where a "station" includes samples at a given site, date, and elevation stratum) and to facilitate determination of factors important to these patterns. A benefit of identifying these associations is that we can then apply our statistical analyses to objective, moderately homogeneous station groups based on biologic reality rather than arbitrary (and possibly faulty) groups based on investigator biases.

The numerical assemblage parameters analyzed in this section are defined in Section 5.2.1. Each assemblage parameter value was calculated using data from a single 0.25-m^2 quadrat, including appropriately normalized and combined counts and weights from subsamples. For our analyses the low stratum of elevation was defined as -0.3 m to +0.3 m, the middle stratum as 0.6 m to 0.9 m, and the high as 1.5 m to 1.8 m.

Similarities among all sites and elevations:

Figure 3 shows the relationships among summer and winter data for all elevations and sites. Stations are segregated mainly on the basis of elevation and, within elevation zone, by site. The primary dichotomy is between

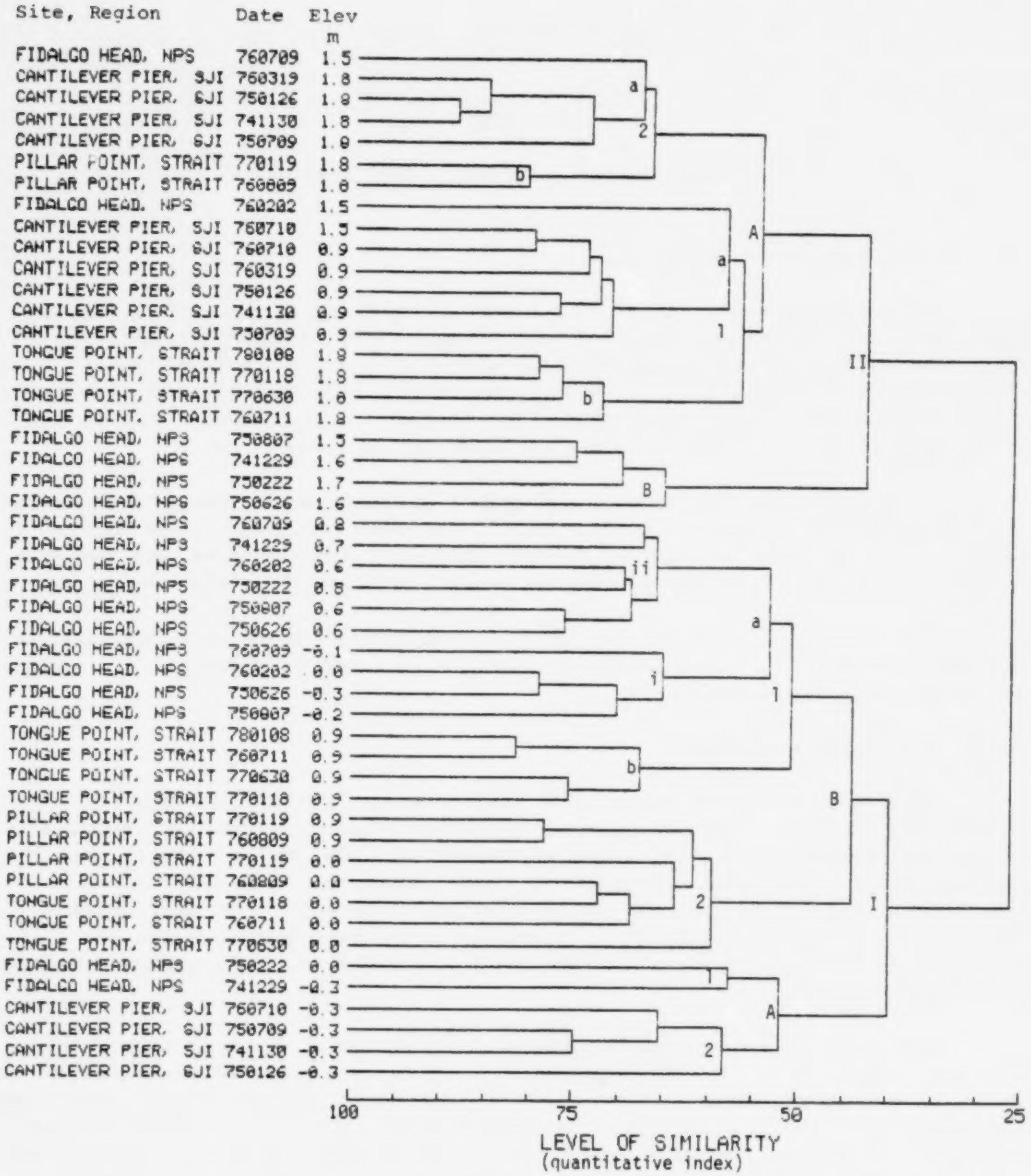


Figure 3. **Relationships among summer and winter rocky intertidal stations, all sites and elevations. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-1.**

-0.3 m to 0.9 m stations (group I) and 0.9 m to 1.8 m stations (group II). All four sites are represented in each major group. This suggests that biotic assemblages above 0.9 m on rocky intertidal habitats in the inland waters of northwestern Washington vary considerably from those below 0.9 m.

Within both groups, the stations are segregated by both site and elevation. For instance, group I-A includes only -0.3 m and 0.0 m stations from Cantilever Pier and Fidalgo Head. Group I-B is more complex, comprising a subgroup (limb) of 0.0 m stations from Tongue and Pillar Points and 0.9 m stations from Pillar Point (limb I-B-2), as well as limbs of 0.9 m stations from Tongue Point (limb I-B-1-b) and -0.3 m to 0.8 m stations from Fidalgo Head (limb I-B-1-a). Within this latter limb, the lower Fidalgo Head stations are segregated from the higher. The indication is that limb I-A represents the most protected low intertidal rock assemblages, limb I-B-1 represents moderately exposed low intertidal assemblages, and limb I-B-2 represents more exposed low intertidal assemblages. The associations among 0.0 m stations from Tongue Point and 0.0 m and 0.9 m stations from Pillar Point suggest that the low intertidal fauna extends higher at Pillar Point than at Tongue Point, implying that Pillar Point is probably more exposed than Tongue Point. Similarly, the association among the 0.9 m stations at Tongue Point and the -0.3 m to 0.8 m stations at Fidalgo Head reinforces the notion that low intertidal species extend higher at Tongue Point than at Fidalgo Head. These comparisons, then, suggest a trend of increasing exposure from Cantilever Pier (least exposed) through Fidalgo Head to Tongue Point and Pillar Point (most exposed). They also indicate that the problems of comparing intertidal assemblages at specified tidal elevations are severe if the degree of exposure varies appreciably among the sites.

The patterns at the upper elevations (0.9 m to 1.8 m) are somewhat different, possibly because the effects of desiccation become more important above 0.9 m. The main dichotomy within this group segregated 1.5 m to 1.7 m Fidalgo Head stations (limb II-B) from upper intertidal stations at the other sites (limb II-A). Within limb II-A, one group (II-A-1) showed an association between 0.9 m Cantilever Pier stations and 1.8 m Tongue Point stations, probably as a consequence of desiccation at 0.9 m at Cantilever Pier resulting from less wave action. The other group (II-A-2) comprises mainly upper stations from Cantilever Pier, but also includes upper stations from Pillar Point and Fidalgo Head. These patterns would probably be somewhat better defined if more data were available from all sites.

Two-way analyses of variance (A.3.12) of elevation (low, mid, and high) crossed with site (all four) indicated similar patterns in variability of numerical assemblage parameters computed from May 1976 data. The interaction between site and elevation was significant at the 0.001 level, an indication of strong elevation effects which vary with site. Site differences were also highly significant.

Seasonal patterns:

Seasonal and between-year effects are much less evident in Figure 3 than site, elevation, and exposure effects. In an attempt to clarify the patterns within a season, we examined summer and winter data separately

(Figures 4 and 5). Generally, the same relationships as those of Figure 3 emerged. The most noticeable difference between summer and winter was that some mid to high elevation stations fell into group I (mainly representing lower intertidal assemblages) in the summer while corresponding stations were in group II (upper intertidal assemblages) in the winter. Between-year differences appear more distinct in the summer data (Figure 4), possibly reflecting the effects of annual differences in dominance in recruitment in the summer. In contrast, the tendency for the rigorous conditions of winter to increase uniformity (i.e., eliminate summer colonization experiments) is apparent in Figure 5, especially for the Strait sites, where elevation effects are frequently stronger than site effects. In limbs I-B-1, I-B-2-b, and II-A-2-a-ii, for example, the Strait stations segregated across sites by elevation.

Again, the problems of comparing data from various locations solely on the basis of tidal elevation and without consideration of exposure are indicated. At sites in the Strait, the biota of both lower and upper intertidal assemblages extend to higher elevations than they do at the inner sites. Thus, the intertidal zone is considerably compressed at the inner sites, especially Cantilever Pier. However, it appears that this pattern of compression may be less distinct in the winter, when the effects of desiccation are probably not as severe at protected sites as in summer because of storms and lower temperatures.

Elevation and site effects within region:

Finally, we examined NPS and SJI sites separately from Strait sites. At the NPS and SJI sites (Figure 6), the primary dichotomy segregated -0.3 m to 0.6 m stations (group I) from 0.9 m to 1.8 m stations (group II). Unfortunately, at the interface elevations (0.6 m to 0.9 m), Cantilever Pier stations were mainly from 0.9 m with only one 0.6 m station, whereas Fidalgo Head stations were all at 0.6 m. The consequence of this difference is that the stations from the two lower levels at Fidalgo Head were grouped with stations from the lowest level at Cantilever Pier in group I, whereas the stations from the upper level at Fidalgo Head were grouped with stations from the two upper levels at Cantilever Pier in group II. Because of the difference in levels sampled, the validity of the pattern cannot be determined.

Generally, clustering by elevation was weaker in Figure 6 than at the Strait sites (Figure 7), suggesting stronger vertical zonation in the Strait. Within each elevation range in each region, within-site similarity generally exceeded similarity between sites.

Regressions to partition assemblage parameter variability at each site:

Contributions of annual, seasonal, elevational, and between-sample variations to overall variability at each rocky intertidal site were assessed using the multiple regression model (A.2.1) of Appendix A with y_j an assemblage parameter value. The results are summarized in Table 8.

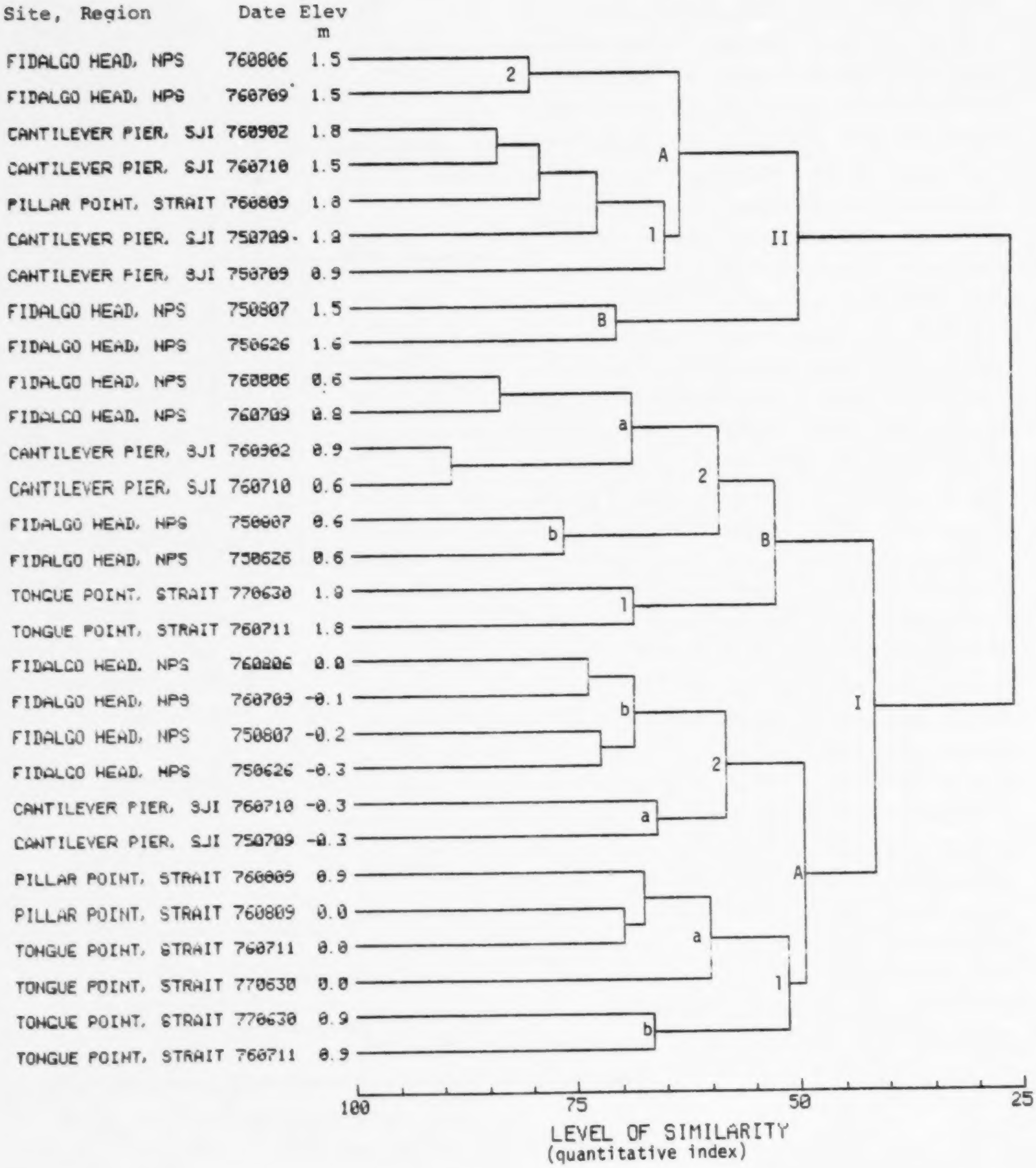


Figure 4. Relationships among summer rocky intertidal stations, all sites and elevations. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-1.

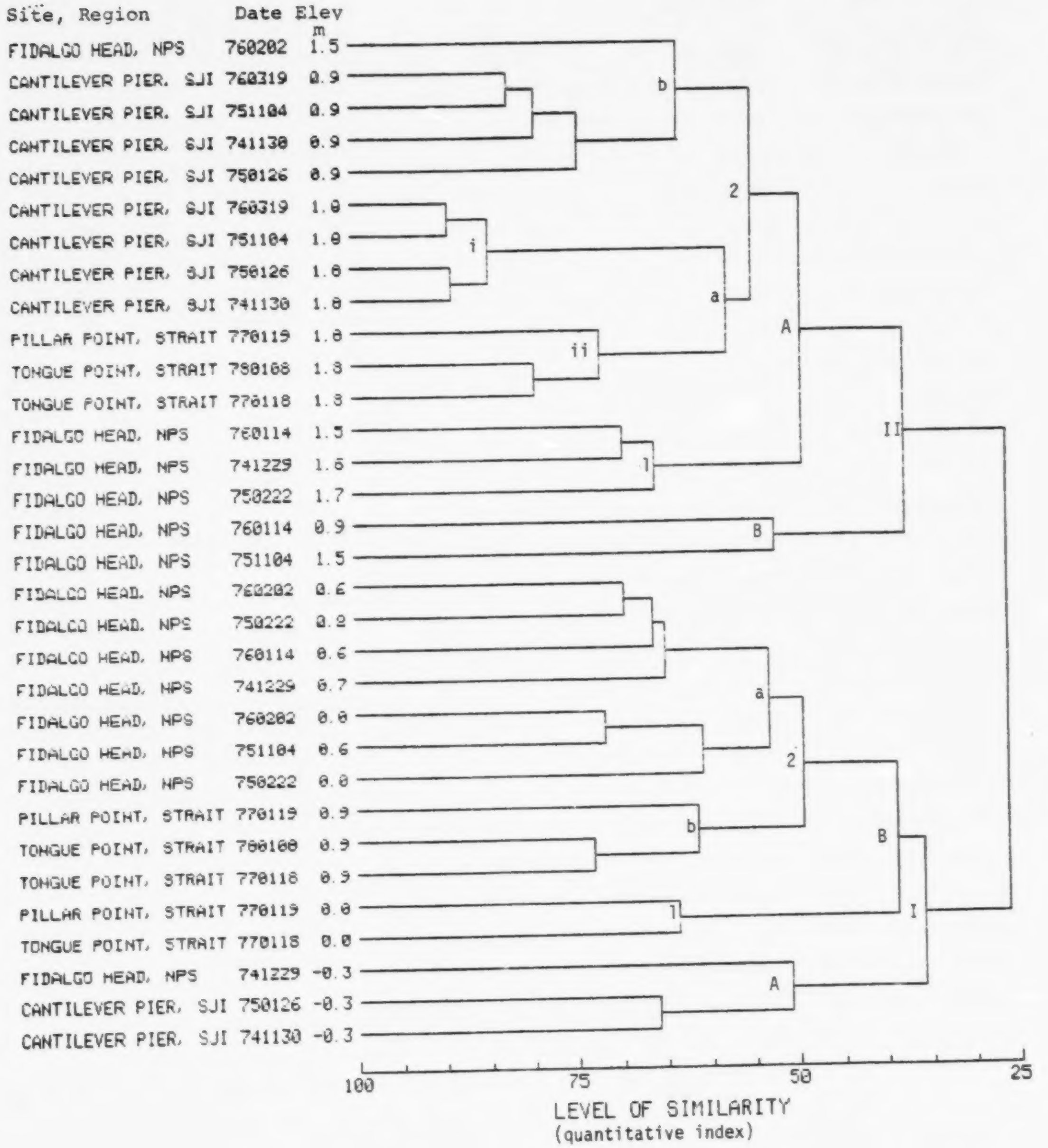


Figure 5. Relationships among winter rocky intertidal stations, all sites and elevations. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-1.

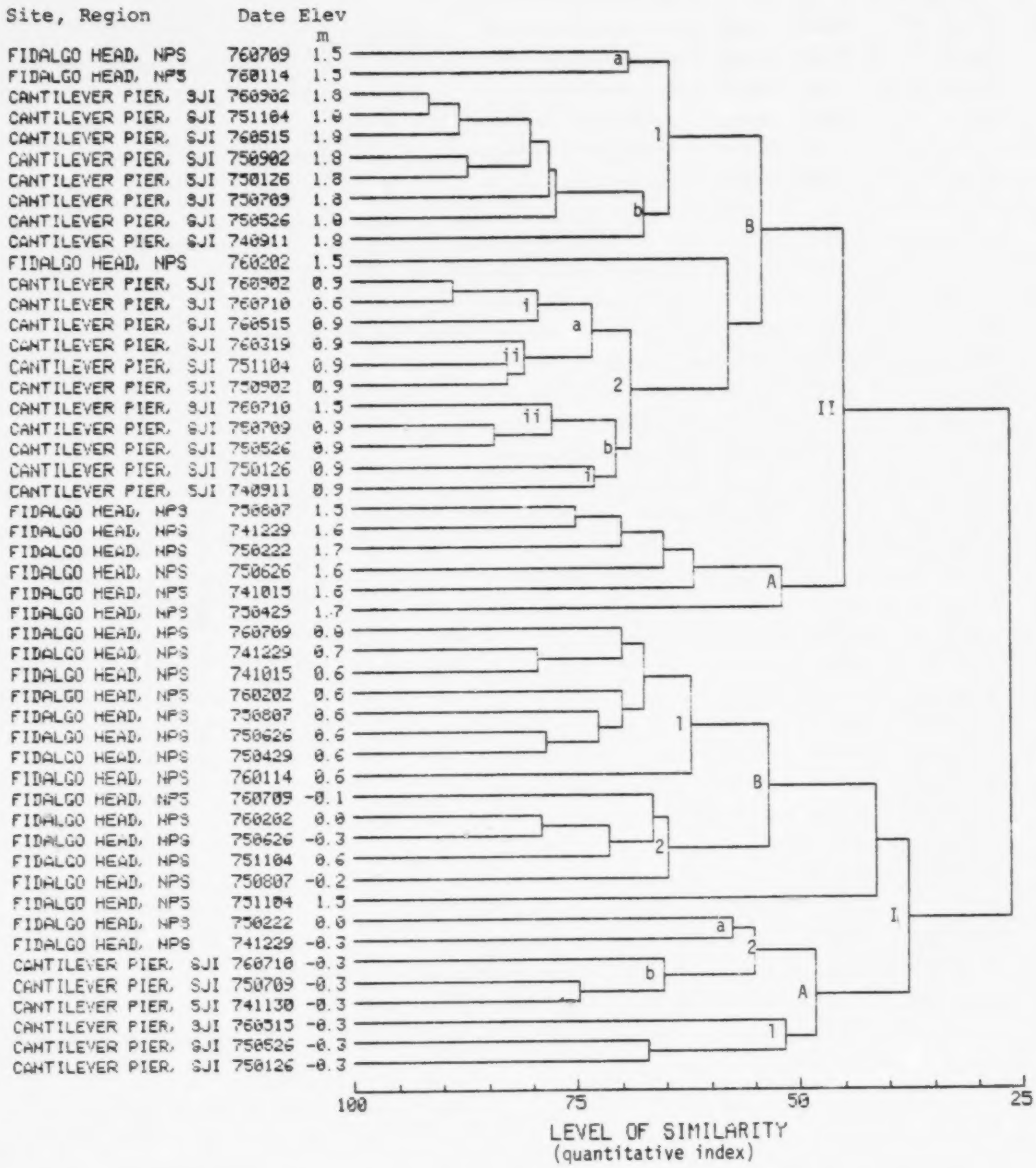


Figure 6. **Relationships among rocky intertidal stations from all months, Fidalgo Head and Cantilever Pier. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-1.**

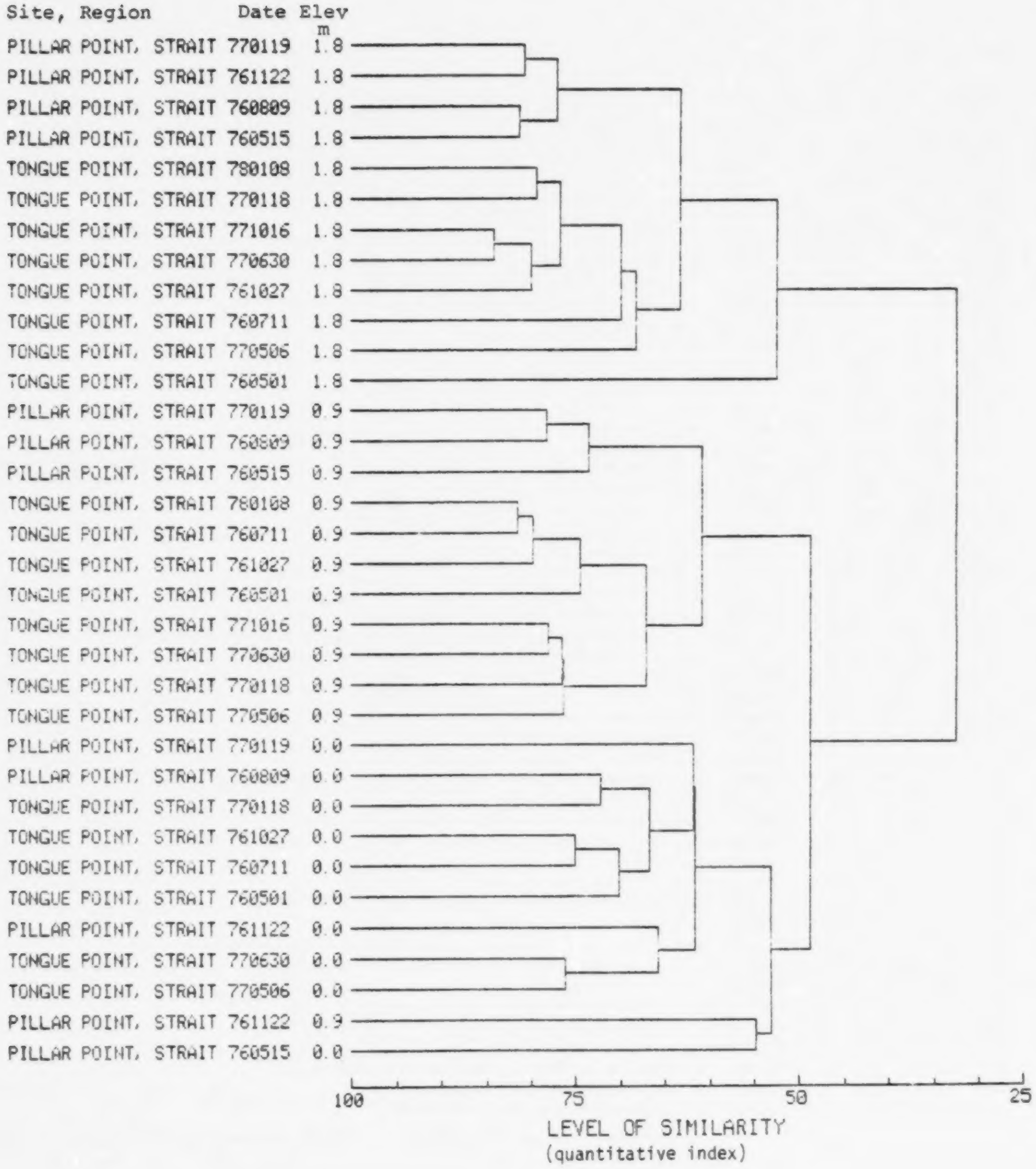


Figure 7. Relationships among rocky intertidal Strait stations, all seasons. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-1.

TABLE 8. RESULTS OF REGRESSIONS TO PARTITION ASSEMBLAGE PARAMETER VARIABILITY, ROCKY INTERTIDAL SITES

Site	$y^\dagger$	Regression Equation (standard deviations of coefficients in parentheses)	Contributions to R^2 * Elevation (x_1)	Elevation Squared (x_2)	Season (x_3)	Date (x_4)	Total R^2	Residual Standard Deviation
Tongue Point	S_p	$30.3 + 2.25x_1 - 4.33x_2 + 2.41x_3 - 0.13x_4$ (118) (3.67) (1.85) (1.65) (1.53)	25.6%	+ 3.7%	+ 2.0%	+ 0.0%	= 31.3%	7.26
	S_a	$= 265 - 3.73x_1 - 9.39x_2 + 7.68x_3 + 4.09x_4$ (186) (5.81) (2.93) (2.62) (2.41)	60.7	3.5	2.1	1.0	67.3	11.5
	$\log_{10}(N_a+1)$	$= 27.5 + 1.46x_1 - 0.71x_2 + 0.23x_3 + 0.40x_4$ (8.08) (0.25) (0.13) (0.11) (0.11)	2.9	23.5	0.1	9.8	36.3	0.498
	$\log_{10}(W_p+1)$	$= 6.75 + 0.16x_1 - 0.53x_2 + 0.42x_3 + 0.12x_4$ (8.81) (0.27) (0.14) (0.12) (0.11)	51.3	5.7	4.2	0.5	61.7	0.543
	% plant cover	$= 1418 - 17.1x_1 - 5.10x_2 + 9.05x_3 + 19.5x_4$ (462) (14.5) (7.30) (6.60) (5.98)	27.9	0.7	0.0	7.5	36.1	28.2
Pillar Point	S_p	$= 328 + 18.4x_1 - 14.7x_2 + 5.62x_3 + 4.52x_4$ (233) (4.58) (2.34) (2.08) (3.02)	30.0	25.4	3.5	1.4	60.3	7.71
	S_a	$541 + 32.3x_1 - 23.6x_2 + 0.88x_3 - 6.61x_4$ (428) (8.43) (4.30) (3.82) (5.56)	20.4	25.7	0.3	1.2	47.6	14.2
	$\log_{10}(N_a+1)$	$= 11.3 + 0.46x_1 - 0.06x_2 + 0.06x_3 + 0.18x_4$ (17.8) (0.35) (0.18) (0.16) (0.23)	15.9	0.1	0.0	0.9	16.9	0.590
	$\log_{10}(W_p+1)$	$= 25.3 + 0.40x_1 - 0.84x_2 + 0.54x_3 + 0.36x_4$ (20.3) (0.99) (0.20) (0.18) (0.26)	54.4	9.0	3.7	1.0	68.1	0.673
	% plant cover	$723 + 12.9x_1 - 18.0x_2 + 6.31x_3 - 8.50x_4$ (974) (19.1) (9.82) (8.61) (12.7)	17.9	4.2	1.2	0.6	23.9	31.5
Cantilever Pier	S_p	$= 207 - 7.04x_1 - 0.23x_2 - 0.34x_3 + 2.93x_4$ (54.5) (1.32) (0.73) (0.93) (0.72)	57.3	0.0	0.6	4.8	62.7	4.78
	S_a	$= 282 + 4.50x_1 - 5.52x_2 + 0.10x_3 + 3.94x_4$ (47.2) (1.14) (0.63) (0.81) (0.63)	28.2	21.6	2.5	11.3	63.6	4.14
	$\log_{10}(N_a+1)$	$= 12.7 + 1.32x_1 - 0.74x_2 + 0.05x_3 + 0.20x_4$ (5.60) (0.14) (0.07) (0.10) (0.07)	1.3	41.0	1.3	3.2	46.8	0.491
	$\log_{10}(W_p+1)$	$3.68 + 0.39x_1 - 0.74x_2 + 0.08x_3 - 0.02x_4$ (7.19) (0.17) (0.10) (0.12) (0.10)	44.6	17.8	0.1	0.0	62.5	0.631
Fidalgo Head	S_p	$130 - 10.2x_1 + 2.06x_2 + 2.88x_3 - 1.56x_4$ (43.8) (0.93) (0.39) (0.65) (0.58)	52.2	7.0	2.5	1.4	63.1	4.24
	S_a	$= 70.8 - 3.95x_1 - 1.53x_2 + 1.18x_3 + 1.18x_4$ (87.7) (1.86) (0.78) (1.30) (1.16)	36.5	1.3	0.6	0.3	38.7	8.49
	$\log_{10}(N_a+1)$	$= 12.4 + 0.05x_1 - 0.35x_2 + 0.06x_3 + 0.20x_4$ (7.25) (0.15) (0.06) (0.11) (0.10)	41.8	8.0	0.5	1.1	51.4	0.702
	$\log_{10}(W_a+1)$	$= 7.82 - 0.14x_1 - 0.29x_2 - 0.07x_3 + 0.14x_4$ (7.96) (0.17) (0.07) (0.12) (0.11)	41.2	5.2	0.0	0.4	46.8	0.770

---

*R^2, the percentage of total variability explained by the multiple regression model (A.2.1) of Appendix A, is defined by (A.2.3).

†The numerical assemblage parameters S_p, S_a, etc. used as dependent variables y_j in (A.2.1) are defined in Section 5.2.1. The subscripts j of (A.2.1) have been omitted in this table for conciseness.

The parameters S_p, S_a, and N_a were considered at all the sites. W_p was included for all sites except Fidalgo Head where the plant weight data were known to contain errors. W_a was considered at Fidalgo Head in place of W_p; W_a could not be computed at the other sites because animal weight data was missing from most records except at Fidalgo Head. Similarly, percent plant cover could be considered only at the Strait sites because it was not recorded at the others.

It should also be noted that examination of plots of residuals from the regressions of Table 8 indicated errors in some of the data, most notably questionable "abiotic" samples at Fidalgo Head. It also appeared that observations at elevations less than -0.3 m and greater than 2.1 m might have had too much influence on the fit. However, when the regressions were rerun with questionable and extreme observations omitted there were no dramatic changes in the results.

Table 8 indicates that elevation effects account for 30 to 60 percent of the variability in S_p, 35 to 65 percent in S_a, 15 to 50 percent in N_a, and around 60 percent of weight variability at each site. One or both coefficients are generally significant. Elevation contributes less significantly to variability in percent plant cover.

In all cases one or both elevation coefficients are negative, corresponding to a decrease in parameter values at high elevations. In some cases the decrease is linear and in others, for example S_a at Pillar Point, the maximum parameter value occurs at a middle elevation rather than at the lowest. Values of S_a predicted by the regression equation at Pillar Point are plotted in Figure 8.

Seasonal effects are significant for S_p at Pillar Point and Fidalgo Head, for W_p at both Strait sites, and for animals as well at Tongue Point. However, they account for less than 5 percent of the variability in all cases. The positive season coefficients indicate higher weights and numbers in spring and summer than in fall and winter.

Time trends, represented by the date coefficients, generally account for less than 10 percent of the variability in assemblage parameters. Positive date coefficients for N_a indicate an increase in number of animals over the course of the studies. The increase is significant at the three sites sampled both before and after the large spring 1976 barnacle recruitment and is probably due to that event. The only other time trends which appear to be significant are an increase in percent plant cover at Tongue Point, increases in S_p and S_a at Cantilever Pier, and a decrease in S_p at Fidalgo Head. The decrease at Fidalgo Head may be real since a separate regression analysis of plant weights at low elevations there also indicated a decrease with time, but final conclusions cannot be drawn until corrected plant weight data are available for analysis. The increase in percent plant cover at Tongue Point may be real or may be due to model inadequacy since R^2 for this parameter is low at both sites where it was computed. The increases in number of taxa at Cantilever Pier are the most significant changes with time. Nyblade hypothesizes that they may be due to a dense monoculture of

Fucus which dominated the mid intertidal in the first year of the study, leading to reduced species richness in that year.

When both year-to-year and seasonal effects were eliminated by considering only July 1976 data at each of the three sites where gradient samples were taken at that time, it was possible to fit quadratic equations in elevation which generally explained 70 to 90 percent of the variability in the assemblage parameters.

```
    47. +             2     8
        -       2           4
        -                   8     2
        -
        - 6
    34. + 4
        - 8                             2
        -
        -
        -
 S  21. +
  a     -                                     8
        -                                     4
        -                                     8
        -
     8. +
        -
        -
        -                                           2
        -
    -5. +
          +---------+---------+---------+---------+---------+
       0.00                1.00                2.00
                 0.50                1.50                2.50

                                 Elevation, m
```

Figure 8. Predicted number of animal taxa S_a at Pillar Point from regression. Predictor variables in (A.2.1) are elevation and its square, season, and date as defined in Section A.2 of Appendix A. Numbers are number of data points at the position where they are plotted.

Problems with the multiple regression model:

The regression analyses we have discussed provide useful indications of the contributions of elevation, season, and year effects to the overall variability in the data. However, we do not recommend the multiple regression model as a predictive model for reasons discussed in Appendix A.

Among the problems of the multiple regression model, one which showed up most clearly in the rocky intertidal regressions was heterogeneity of variances of the errors. This problem was evident in some of the plots of residuals (observed - predicted values) versus predicted values such as Figure 9. This figure, like Figure 8, was computed from values of S_a at Pillar Point. Large positive and negative residuals tend to be associated with large predicted values in the figure, indicating that larger error variances are associated with larger values of S_a. Hence the regression assumption that the errors e_j in (A.2.1) have equal variances is violated.

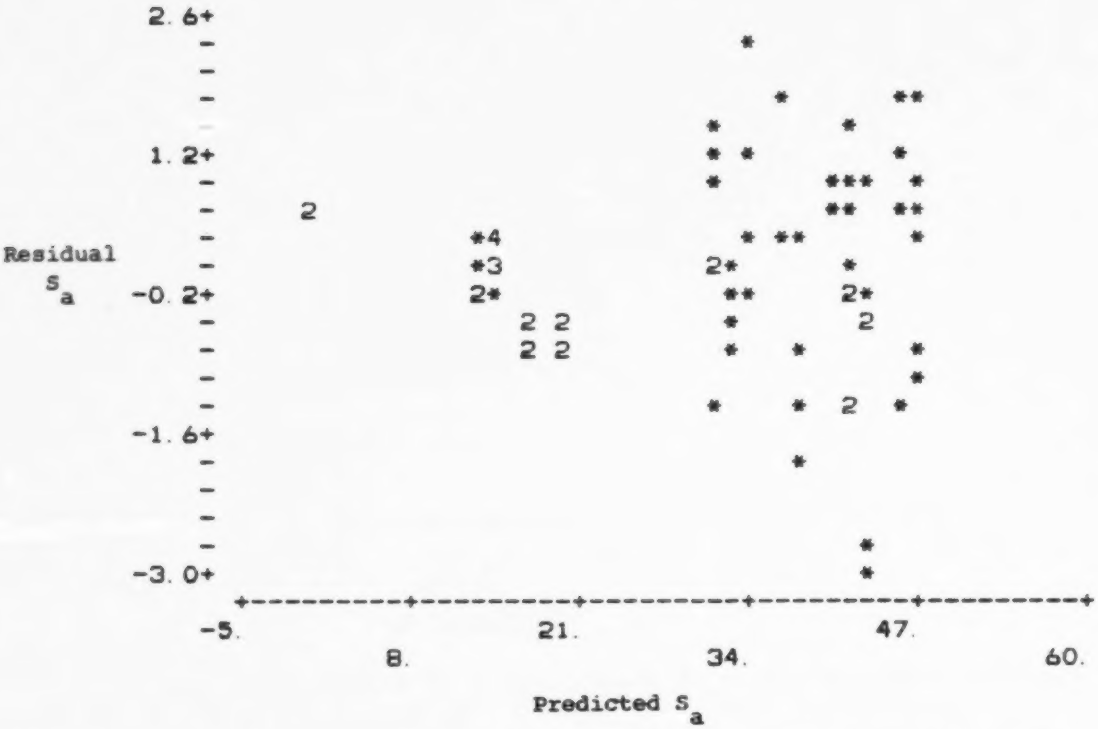


Figure 9. Residual versus predicted number of animal taxa S_a at Pillar Point from regression. Predictor variables in (A.2.1) are elevation and its square, season, and date as defined in Section A.2 of Appendix A. Numbers are number of data points at the position where they are plotted; * indicates a single point.

Since elevation is the dominant contributor to variability in the numerical assemblage parameters, Figure 9 indicates that the residual variability in these parameters may vary with elevation. Therefore, our remaining analyses looked at low, mid, and high elevations separately. Within one of these strata, numerical assemblage parameter values are relatively uniform and hence statistical models which assume homogeneity of variances are more likely to be applicable.

Analysis of variance of assemblage parameters to assess site and season effects within a rocky intertidal elevation stratum, Strait sites:

Since they appeared to be quite different from northern Puget Sound sites, the Strait sites were first analyzed separately. Four replicates per stratum of elevation were available at each site for each season from spring 1976 to spring 1977, providing 10 groups of size $n_i = 4$ for the one-way analysis of variance model (A.3.1) in each stratum. Orthogonal contrasts were used to partition variability in assemblage parameter values into percentages due to site and season differences. Results are summarized in Table 9. The groups and their means are shown in Figure 10.

All highly significant site differences occur in spring data. The huge spring 1976 difference in animal counts is due to the fact that Tongue Point was sampled before and Pillar Point after the large barnacle recruitment. Site differences contribute more than half of the Factor SS (see Table A-2 for definition) for S_a and H'_a at the low elevation; N_a, W_p, and H'_a at the mid elevation; and S_p, N_a, W_p, and H'_p at the high elevation.

The largest seasonal differences involve spring data in all cases but one, a further indication that spring is the least predictable season. Significant contrasts involving S_p are primarily due to larger numbers of plant species in spring samples. Those for N_a are due to the Tongue Point samples taken before the May barnacle recruitment, but the H'_a contrasts appear to reflect an increase in diversity in the fall and winter resulting from the normal attrition of juveniles that peak in density in spring and summer.

Significant differences in percent plant cover must be interpreted with caution for two reasons. The first is that tests for homogeneity of variance for this parameter reflected differences in group variances significant at the 0.01 level at both the low and high elevations. Second, percent plant cover was missing for a few samples. Missing values were replaced by means of the available observations in the same group in order to maintain equal group sizes $n_i = 4$.

An arcsine transformation was tried without success for stabilizing variances of percent plant cover. The large heterogeneous replicate variances of this parameter remained a barrier to prediction and change detection. Hence we will not discuss percent plant cover further.

Among the other parameters, there was some evidence of variance heterogeneity in $\log_{10}(N_a+1)$ at the low elevation, $\log_{10}(W_p+1)$ at the mid, and H'_a at both low and mid. When all elevations were considered together, all except S_a and H'_p exhibited differences significant at the 0.01 level, so the separate analyses for separate elevation strata were clearly called for.

TABLE 9. CONTRIBUTIONS OF SITE AND SEASON DIFFERENCES TO ASSEMBLAGE PARAMETER VARIABILITY, ROCKY STRAIT SITES

	% OF FACTOR SS[†]						
	S_p[#]	S_a	$\log_{10}(N_a + 1)$	$\log_{10}(W_p + 1)$	H'_a	H'_p	Cover
LOW ELEVATION:							
Site (Tongue vs. Pillar Point):							
Spring 1976	14%	41%*	32%	0%	4%	1%	0%
Summer 1976	1	3	5	0	24	13	8
Fall 1976	0	3	6	1	1	2	15
Winter 1977	0	2	0	0	1	19	11
Spring 1977	0	21	0	0	65*	0	2
Season (averages of the two sites):							
Spring 1976 vs. Summer 1976	34*	2	22	1	1	2	5
Fall 1976 vs. Winter 1977	14	24	7	27	2	54	12
Spring/Summer vs. Fall/Winter	18*	4	11	26	1	1	42*
Spring 1976-Winter 1977 vs. Spring 1977	19*	0	17	45	1	8	5
	100%	100%	100%	100%	100%	100%	100%
MID ELEVATION:							
Site (Tongue vs. Pillar Point):							
Spring 1976	18%	1%	3%	2%	4%	15%	2%
Summer 1976	6	8	12	2	41	2	7
Fall 1976	1	15	44	51	10	7	1
Winter 1977	12	17	1	9	1	24	10
Spring 1977	7	2	12	0	1	0	28
Season (averages of the two sites):							
Spring vs. Summer	1	5	1	0	3	0	0
Fall vs. Winter	33	4	14	14	19	0	29
Spring/Summer vs. Fall/Winter	7	43	13	12	7	3	22
Spring 1976-Winter 1977 vs. Spring 1977	15	5	0	10	14	49	1
	100%	100%	100%	100%	100%	100%	100%
HIGH ELEVATION:							
Site (Tongue vs. Pillar Point):							
Spring 1976	4%	1%	55%*	22%	17%	14%	6%
Summer 1976	3	3	1	2	1	4	1
Fall 1976	2	1	3	15	0	2	1
Winter 1977	24	0	0	8	1	48	12
Spring 1977	24	30	6	23	1	3	27
Season (averages of the two sites):							
Spring vs. Summer	0	2	14*	0	9	9	1
Fall vs. Winter	10	0	0	2	1	1	49*
Spring/Summer vs. Fall/Winter	11	45	16*	9	56*	2	3
Spring 1976-Winter 1977 vs. Spring 1977	22	18	5	19	14	17	0
	100%	100%	100%	100%	100%	100%	100%

[†] The Factor SS represents the fraction of the total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

[#] Number of plant taxa S_p and the other numerical assemblage parameters included in this table are defined in Section 5.2.1.

[*] Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for a parameter at one elevation but not another because the overall significance of the Factor SS is higher in the first case than in the second.

Percent Plant Cover

Low Elevation

```
                           POOLED ST. DEV. =       19.8
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site         Date  Elev (BASED ON POOLED STANDARD DEVIATION)
                        m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  0.0                                           I*********I*********I
Pillar Point  760515  0.0                                         I*********I*********I
Tongue Point  760711  0.0                                         I*********I*********I
Pillar Point  760809  0.0                            I*********I*********I
Tongue Point  761027  0.0                                      I*********I*********I
Pillar Point  761122  0.0                    I*********I*********I
Tongue Point  770118  0.0            I*********I*********I
Pillar Point  770119  0.0                         I*********I*********I
Tongue Point  770506  0.0                                        I*********I*********I
Pillar Point  770505  0.0                                  I*********I*********I
                            +---------+---------+---------+---------+---------+---------+
                            0.        20.       40.       60.       80.       100.      120.
```

Mid Elevation

```
                           POOLED ST. DEV. =       27.4
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site         Date  Elev (BASED ON POOLED STANDARD DEVIATION)
                        m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  0.9                           I*************I*************I
Pillar Point  760515  0.9                       I*************I*************I
Tongue Point  760711  0.9                      I*************I*************I
Pillar Point  760809  0.9                              I*************I*************I
Tongue Point  761027  0.9               I*************I*************I
Pillar Point  761122  0.9                  I*************I*************I
Tongue Point  770118  0.9                       I*************I*************I
Pillar Point  770119  0.9                             I*************I*************I
Tongue Point  770506  0.9                   I*************I*************I
Pillar Point  770505  0.9                                I*************I*************I
                            +---------+---------+---------+---------+---------+---------+
                            0.        20.       40.       60.       80.       100.      120.
```

High Elevation

```
                           POOLED ST. DEV. =       27.4
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site         Date  Elev (BASED ON POOLED STANDARD DEVIATION)
                        m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  1.8       I*********I********I
Pillar Point  760515  1.8                I********I********I
Tongue Point  760711  1.8            I*********I********I
Pillar Point  760809  1.8               I*********I********I
Tongue Point  761027  1.8     I*********I********I
Pillar Point  761122  1.8        I*********I********I
Tongue Point  770118  1.8                  I*********I********I
Pillar Point  770119  1.8                              I*********I********I
Tongue Point  770506  1.8                      I********I*********I
Pillar Point  770505  1.8    I********I********I
                            +---------+---------+---------+---------+---------+---------+
                          -30.       0.        30.       60.       90.       120.      150.
```

Figure 10. Group means from analysis of variance of Strait rocky intertidal numerical assemblage parameters (defined in Section 5.2.1) with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations. The one-way analysis of variance model (A.3.1) of Appendix A with $n_i = 4$ in each group was used, with separate analyses for each assemblage parameter at each elevation.

Number of Animal Taxa S_a

Low Elevation

```
                             POOLED ST. DEV. =        12.2
                             INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site        Date   Elev  (BASED ON POOLED STANDARD DEVIATION)
                         m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501   0.0                               I********I********I
Pillar Point  760515   0.0     I********I********I
Tongue Point  760711   0.0                          I********I*******I
Pillar Point  760809   0.0                   I********I********I
Tongue Point  761027   0.0                           I********I********I
Pillar Point  761122   0.0                    I********I*******I
Tongue Point  770118   0.0            I********I********I
Pillar Point  770119   0.0      I********I********I
Tongue Point  770506   0.0                            I********I********I
Pillar Point  770505   0.0            I********I*******I
                             +---------+---------+---------+---------+---------+---------+
                            10.       24.       38.       52.       66.       80.       94.
```

Mid Elevation

```
                             POOLED ST. DEV. =        14.4
                             INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site        Date   Elev  (BASED ON POOLED STANDARD DEVIATION)
                         m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501   0.9                              I**************I*************I
Pillar Point  760515   0.9                                  I**************I*************I
Tongue Point  760711   0.9                    I**************I*************I
Pillar Point  760809   0.9                               I**************I*************I
Tongue Point  761027   0.9                     I**************I*************I
Pillar Point  761122   0.9     I**************I*************I
Tongue Point  770118   0.9          I**************I*************I
Pillar Point  770119   0.9                           I**************I*************I
Tongue Point  770506   0.9                    I**************I*************I
Pillar Point  770505   0.9              I**************I*************I
                             +---------+---------+---------+---------+---------+---------+
                            10.       20.       30.       40.       50.       60.       70.
```

High Elevation

```
                             POOLED ST. DEV. =        6.13
                             INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site        Date   Elev  (BASED ON POOLED STANDARD DEVIATION)
                         m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501   1.8      I**********I*********I
Pillar Point  760515   1.8          I**********I*********I
Tongue Point  760711   1.8              I**********I*********I
Pillar Point  760809   1.8        I**********I*********I
Tongue Point  761027   1.8                       I**********I*********I
Pillar Point  761122   1.8                    I**********I*********I
Tongue Point  770118   1.8                      I**********I*********I
Pillar Point  770119   1.8                    I**********I*********I
Tongue Point  770506   1.8                                  I**********I*********I
Pillar Point  770505   1.8              I**********I*********I
                             +---------+---------+---------+---------+---------+---------+
                            0.0       6.0       12.0      18.0      24.0      30.0      36.0
```

Figure 10 (continued)

Number of Plant Taxa S_p

Low Elevation

```
                           POOLED ST. DEV. =        4.92
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site        Date  Elev (BASED ON POOLED STANDARD DEVIATION)
                       m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  0.0                                  I*****I*****I
Pillar Point  760515  0.0                   I*****I*****I
Tongue Point  760711  0.0        I*****I*****I
Pillar Point  760809  0.0           I******I*****I
Tongue Point  761027  0.0   I******I*****I
Pillar Point  761122  0.0     I*****I******I
Tongue Point  770118  0.0              I******I*****I
Pillar Point  770119  0.0               I*****I******I
Tongue Point  770506  0.0                         I*****I*****I
Pillar Point  770505  0.0                      I*****I******I
                           +---------+---------+---------+---------+---------+---------+
                          8.0      16.0      24.0      32.0      40.0      48.0      56.0
```

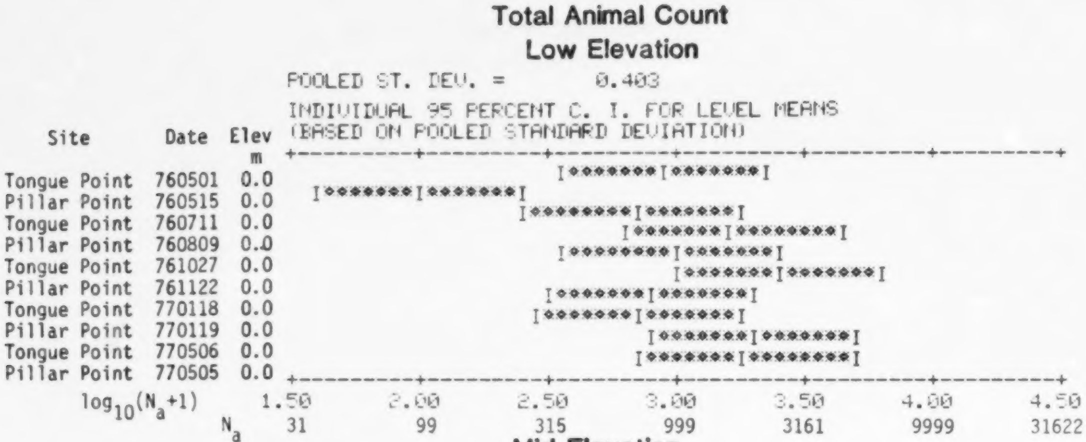
Mid Elevation

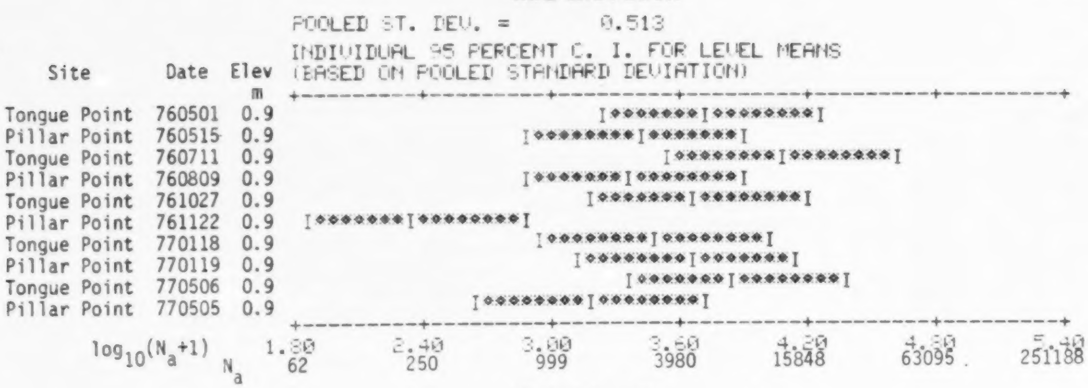
```
                           POOLED ST. DEV. =        7.08
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site        Date  Elev (BASED ON POOLED STANDARD DEVIATION)
                       m   +---------+---------+---------+---- ---+---------+---------+
Tongue Point  760501  0.9           I*********I**********I
Pillar Point  760515  0.9                            I**********I*********I
Tongue Point  760711  0.9           I**********I*********I
Pillar Point  760809  0.9                     I*********I**********I
Tongue Point  761027  0.9      I*********I**********I
Pillar Point  761122  0.9   I*********I*********I
Tongue Point  770118  0.9              I*********I*********I
Pillar Point  770119  0.9                            I*********I**********I
Tongue Point  770506  0.9                    I*********I*********I
Pillar Point  770505  0.9                              I*********I*********I
                           +---------+---------+---------+---------+---------+---------+
                          7.0      14.0      21.0      28.0      35.0      42.0      49.0
```

High Elevation

```
                           POOLED ST. DEV. =        4.87
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site        Date  Elev (BASED ON POOLED STANDARD DEVIATION)
                       m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  1.8         I*********I********I
Pillar Point  760515  1.8  I*********I********I
Tongue Point  760711  1.8        I*********I*********I
Pillar Point  760809  1.8  I*********I*********I
Tongue Point  761027  1.8         I*********I*********I
Pillar Point  761122  1.8     I*********I********I
Tongue Point  770118  1.8                       I*********I*********I
Pillar Point  770119  1.8      I*********I*********I
Tongue Point  770506  1.8                          I*********I********I
Pillar Point  770505  1.8         I*********I********I
                           +---------+---------+---------+---------+---------+---------+
                          0.0       5.0      10.0      15.0      20.0      25.0      30.0
```

Figure 10 (continued)





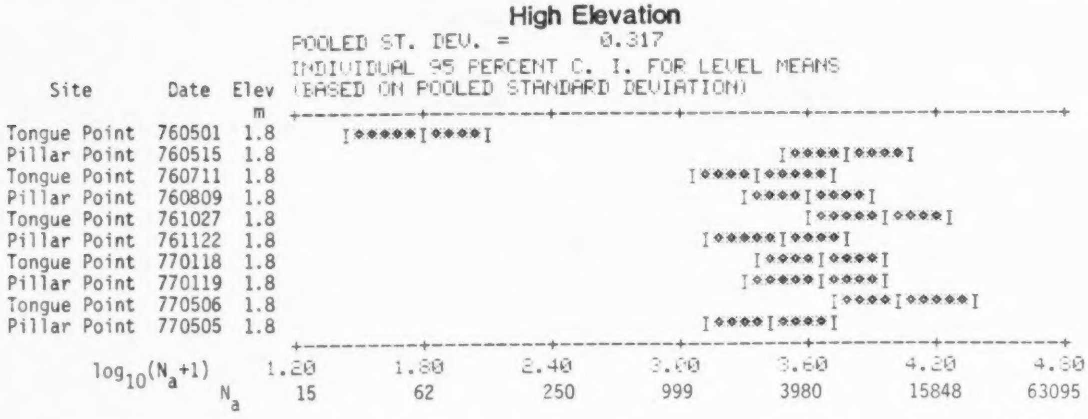
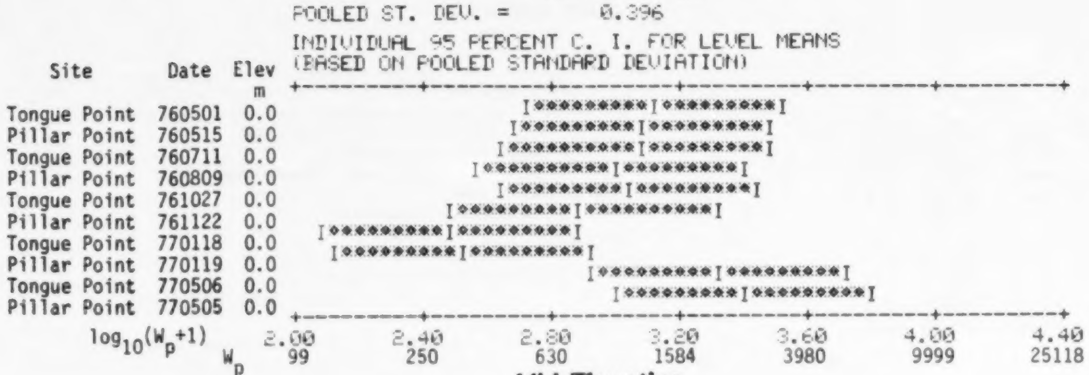


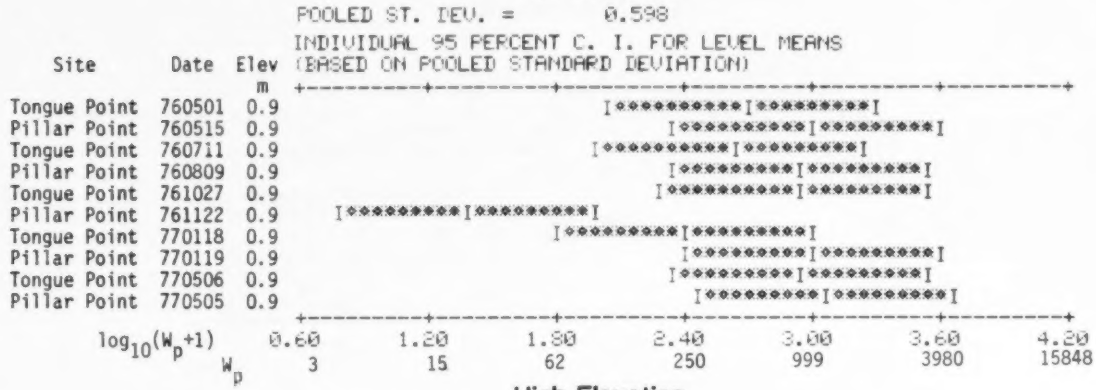
Figure 10 (continued) The x-axis divisions on these plots are labelled in log units with the corresponding counts given below.

Total Plant Weight

Low Elevation



Mid Elevation



High Elevation

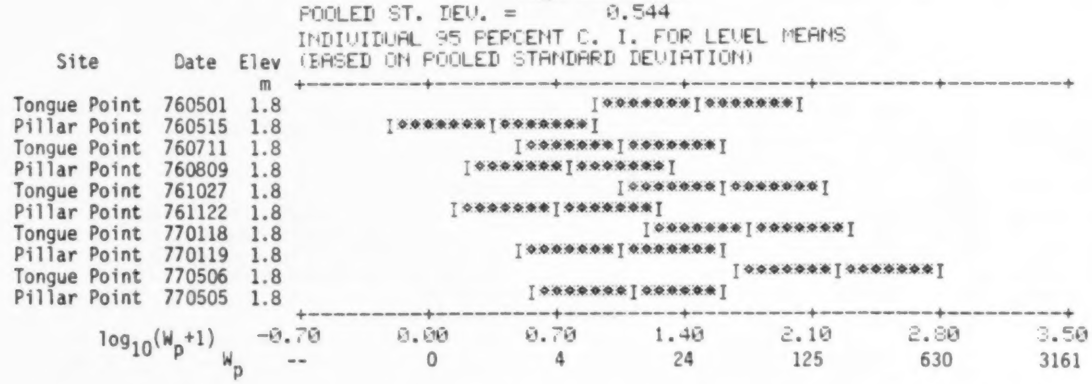
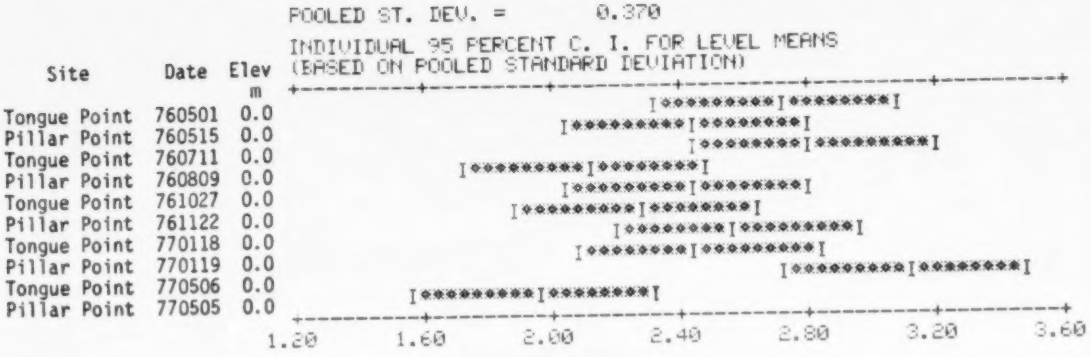


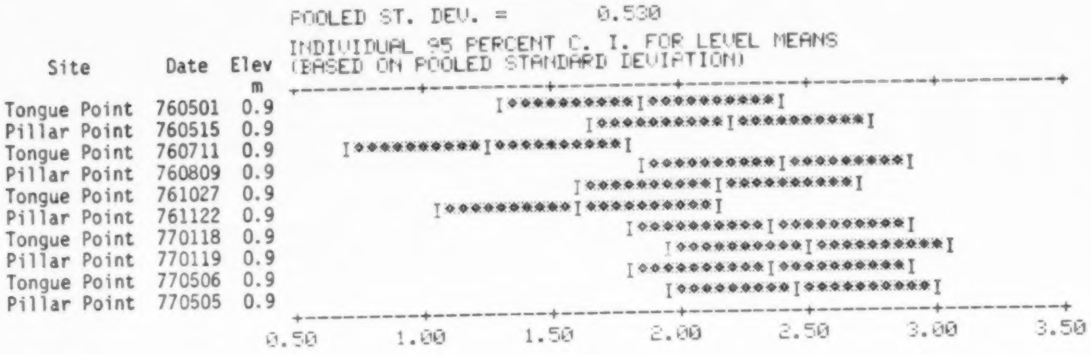
Figure 10 (continued) The x-axis divisions on these plots are labelled in log units with the corresponding weights given below.

Animal Diversity H'_a

Low Elevation



Mid Elevation



High Elevation

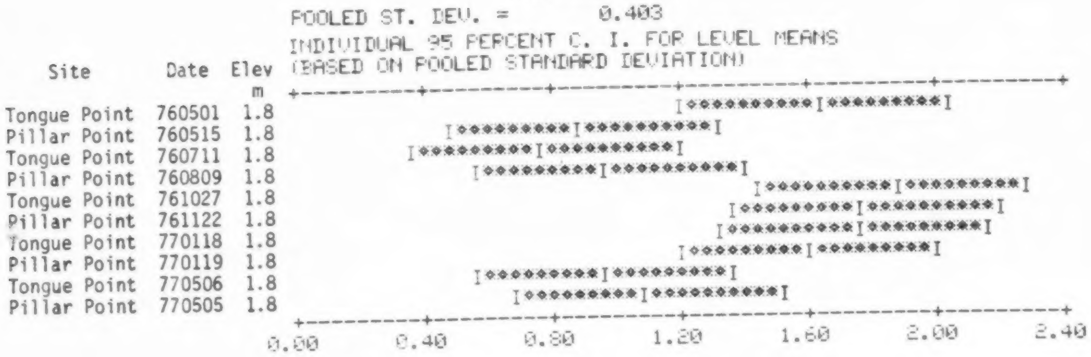


Figure 10 (continued)

Plant Diversity H'_p

Low Elevation

```
                           POOLED ST. DEV. =       0.451
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site      Date    Elev (BASED ON POOLED STANDARD DEVIATION)
                       m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  0.0       I************I************I
Pillar Point  760515  0.0          I************I************I
Tongue Point  760711  0.0      I************I************I
Pillar Point  760809  0.0                I************I************I
Tongue Point  761027  0.0  I************I************I
Pillar Point  761122  0.0      I************I************I
Tongue Point  770118  0.0            I************I************I
Pillar Point  770119  0.0                        I************I************I
Tongue Point  770506  0.0              I************I************I
Pillar Point  770505  0.0               I************I************I
                           +---------+---------+---------+---------+---------+---------+
                         -0.10     0.25      0.60      0.95      1.30      1.65      2.00
```

Mid Elevation

```
                           POOLED ST. DEV. =       0.507
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site      Date    Elev (BASED ON POOLED STANDARD DEVIATION)
                       m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  0.9        I************I************I
Pillar Point  760515  0.9                  I************I************I
Tongue Point  760711  0.9          I************I************I
Pillar Point  760809  0.9              I************I************I
Tongue Point  761027  0.9              I************I************I
Pillar Point  761122  0.9        I************I************I
Tongue Point  770118  0.9                I************I************I
Pillar Point  770119  0.9   I************I************I
Tongue Point  770506  0.9                     I************I************I
Pillar Point  770505  0.9                      I************I************I
                           +---------+---------+---------+---------+---------+---------+
                          0.00      0.40      0.80      1.20      1.60      2.00      2.40
```

High Elevation

```
                           POOLED ST. DEV. =       0.491
                           INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
    Site      Date    Elev (BASED ON POOLED STANDARD DEVIATION)
                       m   +---------+---------+---------+---------+---------+---------+
Tongue Point  760501  1.8                                   I************I************I
Pillar Point  760515  1.8                       I************I************I
Tongue Point  760711  1.8                         I************I************I
Pillar Point  760809  1.8                   I************I************I
Tongue Point  761027  1.8                      I************I************I
Pillar Point  761122  1.8                          I************I************I
Tongue Point  770118  1.8                                  I************I************I
Pillar Point  770119  1.8           I************I************I
Tongue Point  770506  1.8                                  I************I************I
Pillar Point  770505  1.8                             I************I************I
                           +---------+---------+---------+---------+---------+---------+
                         -0.40     0.00      0.40      0.80      1.20      1.60      2.00
```

Figure 10 (continued)

Year-to-year variability within elevation stratum, rocky Strait sites:

To assess year-to-year variability of numerical assemblage parameters we used summer 1977 and winter 1978 data from Tongue Point not used in the analyses of variance. These data were compared first with Tongue Point data and then with Pillar Point data from the corresponding seasons of the previous year by means of two-sample *t*-tests and Mann-Whitney tests. The results are summarized in Table 10.

Given the number of tests performed and possible violations of *t*-test assumptions, we expect some false indications of significant differences. On the other hand, given the small number of replicates, we expect to miss some significant differences due to lack of power of the tests.

Nevertheless, the table clearly indicates more differences between Pillar Point and Tongue Point data than between the two years of Tongue Point data. The only significant change in winter Tongue Point data was an apparent decrease in plant weight from 53 g per 0.25-m^2 quadrat in the first year to 5 g per quadrat in the second at the high elevation. More changes were evident in summer.

Temporal variability within northern Puget Sound rocky intertidal sites and elevations:

Bimonthly summer and winter data from Cantilever Pier and Fidalgo Head were used to assess variability due to year, season, and date within season. Analyses of variance of the available numerical assemblage parameters were done separately for mid and high elevations at each site. Low elevations were not considered because they were not sampled on some of the dates of interest. The nested model (A.3.13) with Analysis of Variance Table A-3 was used to obtain the results summarized in Table 11.

This table indicates that spatial patchiness, reflected in the residual variance component, contributes more to variability in assemblage parameters than short-term temporal change, reflected in the date-within-season component. In addition, there is evidence that real seasonal and year-to-year changes in numerical assemblage parameters can be expected.

Results for W_p and H'_p at Fidalgo Head are included in Table 11 only to illustrate that bad data may either mask or create significant results. It was in fact the highly significant summer versus winter difference in W_p which led to the discovery of errors in Fidalgo Head plant weight data.

If we discount H'_p at Fidalgo Head, we are left with only one estimate of the date-within-season variance component that is significantly different from zero. This is for S_a at the mid elevation at Cantilever Pier. Table 11 indicates variance heterogeneity in this parameter at this site and elevation, so the indicated significance of the date effect may be incorrect.

The significant summer versus winter and summer 1975 versus 1976 differences in animals reflect the spring 1976 barnacle recruitment as they should. H'_a is less sensitive than numbers to this change. Plant parameters

TABLE 10. MEANS, CONFIDENCE INTERVALS, AND SIGNIFICANCE TESTS FOR STRAIT ASSEMBLAGE PARAMETERS. SUMMER AND WINTER

Tidal Elevation (meters)	Season	Assemblage Parameter [§]	95% CI, Tongue Point, Second Year [†]	Tongue Point First Year Mean	Tongue Point First Year Significance of Difference [*] t-test	Tongue Point First Year Significance of Difference [*] Mann-Whitney	Pillar Point First Year Mean	Pillar Point First Year Significance of Difference t-test	Pillar Point First Year Significance of Difference Mann-Whitney
0.0	Summer	S_p	(1.02,16.48)	17.75	0.0129	0.0304	20.00	0.0382	ns
		S_a	(31.9,101.6)	54.00	ns	ns	52.00	ns	ns
		$\log_{10}(N_a+1)$	(3.07,4.31)	2.83	0.0067	0.0304	3.51	ns	ns
		$\log_{10}(W_p+1)$	(3.10,3.78)	3.06	ns	ns	3.21	ns	ns
		H'_a	(2.59,3.23)	2.80	ns	ns	1.89	ns	ns
		H'_p	(-0.13,0.44)	0.51	0.0346	ns	0.67	0.0370	ns
	Winter	No second year data							
0.9	Summer	S_p	(13.25,26.75)	20.75	ns	ns	27.50	0.0192	0.0304
		S_a	(39.60,65.90)	41.25	ns	ns	52.50	ns	ns
		$\log_{10}(N_a+1)$	(3.97,4.71)	4.07	ns	ns	3.38	0.0058	0.0304
		$\log_{10}(W_p+1)$	(2.68,3.36)	2.61	0.0367	ns	2.93	ns	ns
		H'_a	(1.11,2.92)	1.25	ns	ns	2.38	ns	ns
		H'_p	(0.89,1.66)	0.84	ns	ns	0.99	ns	ns
	Winter	S_p	(13.10,20.90)	22.50	ns	ns	32.50	0.0018	0.0304
		S_a	(17.22,54.78)	31.25	ns	ns	48.00	ns	ns
		$\log_{10}(N_a+1)$	(3.07,4.13)	3.47	ns	ns	3.65	ns	ns
		$\log_{10}(W_p+1)$	(1.71,3.21)	2.39	ns	ns	3.01	ns	ns
		H'_a	(2.07,2.71)	2.34	ns	ns	2.51	ns	ns
		H'_p	(0.48,1.61)	1.09	ns	ns	0.57	ns	ns
1.8	Summer	S_p	(0.60,26.90)	8.00	ns	ns	5.00	ns	0.0304
		S_a	(14.28,31.72)	13.00	ns	ns	9.25	0.0038	0.0304
		$\log_{10}(N_a+1)$	(3.59,4.10)	3.37	0.0456	ns	3.60	0.0477	ns
		$\log_{10}(W_p+1)$	(1.28,3.23)	1.07	ns	ns	0.77	0.0097	0.0304
		H'_a	(1.21,2.26)	0.77	ns	ns	0.98	0.0072	0.0304
		H'_p	(0.24,2.32)	1.02	ns	ns	0.78	ns	ns
	Winter	S_p	(3.83,21.17)	15.50	ns	ns	7.00	ns	ns
		S_a	(10.36,15.14)	17.75	ns	ns	16.75	0.0162	ns
		$\log_{10}(N_a+1)$	(3.03,3.85)	3.65	ns	ns	3.64	ns	ns
		$\log_{10}(W_p+1)$	(0.16,1.40)	1.73	0.0269	0.0304	1.07	ns	ns
		H'_a	(1.55,1.93)	1.74	ns	ns	1.60	ns	ns
		H'_p	(1.18,2.46)	1.37	ns	ns	0.47	0.0027	0.0304

[†] Confidence intervals (CI) are defined by (A.1.6) of Appendix A.

[*] Significance tests (see Section A.4 of Appendix A) compared second-year Tongue Point data (summer 1977 and winter 1978) first with Tongue Point and then with Pillar Point data from the corresponding seasons of the previous year. Four replicates were available at each year/season/site/elevation except for first year/summer/Pillar Point/0.0 m where there were only two. Tests not significant at the 0.05 level are indicated by ns. Significance levels for the *t*-test may not be exact because of variance heterogeneity and lack of normality.

[§] Numerical assemblage parameters included in this table are defined in Section 5.2.1.

TABLE 11. YEAR, SEASON, DATE WITHIN SEASON, AND REPLICATE VARIABILITY AT CANTILEVER PIER AND FIDALGO HEAD.

SITE	ELEVATION	PARAMETER[§]	ESTIMATES OF VARIANCE COMPONENTS[#] RESIDUAL σ^2	DATE WITHIN SEASON σ_t^2	LEVELS OF SIGNIFICANCE* DATE	SUMMER VS WINTER	1975 VS 1976 SUMMER	1975 VS 1976 WINTER	MAX F-RATIO**
Cantilever Pier[†]	mid	S_p	14.2	3.55	ns	ns	ns	--	ns
		S_a	9.57	16.1	0.01	ns	ns	--	0.05
		$\log_{10}(N_a+1)$	0.058	0.019	ns	ns	0.05	--	ns
		$\log_{10}(W_p+1)$	0.369	0.026	ns	0.05	ns	--	0.05
		H'_a	0.137	0.044	ns	ns	ns	--	ns
		H'_p	0.170	0.005	ns	ns	ns	--	0.01
	high	S_p	1.61	0.00	ns	ns	ns	--	ns
		S_a	9.36	0.00	ns	ns	0.05	--	ns
		$\log_{10}(N_a+1)$	0.149	0.00	ns	ns	0.05	--	ns
		$\log_{10}(W_p+1)$	0.271	0.00	ns	ns	ns	--	0.01
		H'_a	0.111	0.012	ns	ns	ns	--	ns
		H'_p	0.075	0.018	ns	ns	ns	--	--
Fidalgo Head[‡]	mid	S_p	10.0	3.93	ns	ns	ns	ns	ns
		S_a	71.0	6.75	ns	ns	ns	ns	0.05
		$\log_{10}(N_a+1)$	0.179	0.00	ns	ns	0.01	ns	ns
		$\log_{10}(W_p+1)$	0.630	0.363	ns	ns	ns	ns	ns
		H'_a	0.191	0.055	ns	ns	ns	ns	ns
		H'_p	0.206	0.061	ns	ns	ns	ns	ns
	high	S_p	1.83	0.320	ns	ns	ns	ns	ns
		S_a	10.5	0.00	ns	0.05	0.05	ns	ns
		$\log_{10}(N_a+1)$	0.314	0.00	ns	0.05	0.01	ns	0.05
		$\log_{10}(W_p+1)$	0.610	0.00	ns	0.001	0.01	ns	ns
		H'_a	0.276	0.00	ns	0.05	ns	ns	ns
		H'_p	0.111	0.094	0.05	ns	ns	ns	ns

*Differences not significant at the 0.05 level are denoted by ns. Omitted entries, denoted by --, correspond to cases where data from which the statistics could be computed were not available.

[†] Four replicates at each of two sampling dates a month or two apart were available for winter 1974-75, summer 1975, and summer 1976 at each elevation at Cantilever Pier. Hence n=4, t=2, and s=3 in Table A-3 of Appendix A for the Cantilever Pier analyses at each elevation.

[‡] Fidalgo Head samples from the same seasons as at Cantilever Pier and, in addition, winter 1976 were used, giving t=2 and s=4 in Table A-3. Most were gradient samples, but at least three were available on each date in each elevation stratum. The first three were selected when more than three were available to obtain n=3 in Table A-3 for the Fidalgo Head analyses.

[§] The numerical assemblage parameters S_p, S_a, etc. are defined in Section 5.2.1.

[#] The residual and date within season variance components are defined as in Table A-3.

**The maximum F-ratio test for variance heterogeneity is defined by (A.3.10).

(excluding those involving bad data) exhibit less temporal variability relative to their sampling variability than animal parameters. No significant summer-versus-winter or year-to-year differences were detected in S_p or H'_p.

There is evidence of variance heterogeneity in $\log_{10}(N_a+1)$, $\log_{10}(W_p+1)$, and H'_p as well as S_a. Hence, nonparametric tests such as the Mann-Whitney may be preferable to *t*-tests and analysis of variance for accurately assessing change.

Finally, we note that replicate variability is larger at Fidalgo Head than at Cantilever Pier for all the parameters except mid elevation S_p. This may be due to data errors, to the fact that most of the Fidalgo Head samples were gradient rather than stratified samples, or to site characteristics.

Relative importance of site and season, North Puget Sound:

To assess the relative importance of site and time differences at Fidalgo Head and Cantilever Pier, the two-way analysis of variance model (A.3.12) was used on mid and high elevation data from three seasons at the two sites. The results are summarized in Table 12.

Residual sampling variability dominates site and season effects and interactions for the most part. However, site differences were indicated at the high elevation for S_p, H'_a, and especially $\log_{10}(N_a+1)$. Numbers of taxa and diversity were higher at Fidalgo Head while $\log_{10}(N_a+1)$ was higher at Cantilever Pier. The latter difference translates into counts of 1,066 per 0.25 m^2 at Cantilever Pier versus 122 per 0.25 m^2 at Fidalgo Head. The estimated variance component due to site for $\log_{10}(N_a+1)$ at the high elevation is 0.41, larger than the estimated replicate variance of 0.23.

Between-site variability, all rocky intertidal sites:

Site differences between North Puget Sound and Strait sites are more significant than those within either of these areas. These differences are quantified in Table 13, which summarizes analyses of summer 1976 data from all rocky intertidal sites. The between-site variance component contributes much more significantly to variability in the data when Strait and northern Sound sites are considered together as in Table 13 than when the latter are considered alone as in Table 12.

Site means from the analyses of Table 13 at each elevation, plotted in Figure 11, illustrate the fact that the large between-area differences in numbers of taxa are due to much greater species richness in the Strait than in the northern Sound. Between-area differences in animal counts and diversities are less clear. Fidalgo Head appears to have larger numbers of animals at the low elevation and smaller numbers at the high than the other three sites while at the mid elevation Pillar Point differs most in terms of animal numbers. Elevation effects, for example the decrease in species richness at the high elevation, are also evident from Figure 11.

TABLE 12. SITE x SEASON ANALYSIS OF VARIANCE, CANTILEVER PIER AND FIDALGO HEAD.

Elevation	Assemblage Parameter§	Site x Season Interaction# $F=MS(\alpha\beta)/MSE$ (Numerator DF=2)	Site† $F=MS(\alpha)/MSE$ (Numerator DF=1)	$\hat{\sigma}^2$=MSE (DF=12)	Site Variance Component $\hat{\sigma}_\alpha^2$	Season‡ F (Numerator DF=2)
mid	S_p	5.28*	<1	21.8	0.00	<1
	S_a	<1	<1	58.6	0.00	2.67
	$\log_{10}(N_a+1)$	<1	<1	0.31	0.00	2.48
	H'_a	1.61	<1	0.31	0.00	1.40
high	S_p	3.85	5.66*	4.33	2.24	1.13
	S_a	<1	<1	5.67	0.00	2.03
	$\log_{10}(N_a+1)$	1.48	17.29**	0.23	0.41	1.17
	H'_a	1.03	7.41*	0.19	0.13	3.56

*Significant at $\alpha=0.05$ level. See Section A.4 of Appendix A for a discussion of significance.

**Significant at $\alpha=0.01$ level.

†The random site effect is represented by α_i in (A.3.12) of Appendix A. The indicated F-statistic tests for significant differences between the sites averaged over seasons.

‡The three seasons included in the analysis were those in which the two sites were sampled on approximately the same dates (fall 1975 and the summer of 1976). Three replicates at each site/season/elevation were included in the analysis. The season effect is β in (A.3.12). Hence MS(β) is the numerator for the season F-statistic, which tests for significant differences among seasons averaged over sites. The denominator MS is MS($\alpha\beta$) for S_p at the mid level and a pooled estimate combining site x season and error contribution for parameters with no significant interaction.

#The interaction F-statistic is used to test whether site differences vary with season (or season differences with site).

§Assemblage parameters are defined in Section 5.2.1.

TABLE 13. ONE-WAY ANALYSIS OF VARIANCE OF SUMMER 1976 ROCKY INTERTIDAL ASSEMBLAGE PARAMETERS, ALL SITES.

Elevation	Parameter[†]	Strait vs. Northern Sound contrast		Remainder of site differences (within area)		Estimates of Variance Components	
		F	significance*	F	significance	Between-Site	Within-Site
low	S_p	22.6	0.001	0.06	ns	14.0	12.1
	S_a	34.6	0.001	4.95	0.05	177.1	72.7
	$\log_{10}(N_a+1)$	5.04	0.05	3.59	0.05	0.102	0.189
	H'_a	19.5	0.001	2.95	ns	0.336	0.256
mid	S_p	69.0	0.001	5.89	0.01	68.3	17.7
	S_a	29.7	0.001	0.03	ns	195.0	147.0
	$\log_{10}(N_a+1)$	1.12	ns	4.09	0.05	0.059	0.190
	H'_a	3.32	ns	3.75	0.05	0.141	0.364
high	S_p	11.3	0.01	0.16	ns	32.7	73.8
	S_a	7.02	0.05	0.10	ns	32.0	147.0
	$\log_{10}(N_a+1)$	35.0	0.001	11.3	0.001	0.441	0.157
	H'_a	0.14	ns	1.53	ns	0.004	0.395

---

*Factors not significant at the 0.05 level are indicated by ns. Significance levels for S_p at the high elevation, S_a at the mid and high, and $\log_{10}(N_a+1)$ at the mid elevation should be interpreted with some caution since the maximum F-statistic (A.3.10) indicated variance heterogeneity in these parameters.

[†] The assemblage parameters S_p, S_a, etc. are defined in Section 5.2.1. The analyses summarized in Table 13 are discussed in Section A.3 of Appendix A.

Low Elevation (-0.3m to 0.3m)

Number of Plant Taxa S_p

```
Site, Region           # of   POOLED ST. DEV. =      3.48
                     Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait    6                           [**********[**********]
Pillar Point, Strait    4                              [************[************]
Cantilever Pier, SJI    6       [**********[**********]
Fidalgo Head, NPS       7       [*********[*********]
                             +---------+---------+---------+---------+---------+---------+
                            9.0      12.0      15.0      18.0      21.0      24.0      27.0
```

Number of Animal Taxa S_a

```
Site, Region           # of   POOLED ST. DEV. =      8.53
                     Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait    6                                     [******[*******]
Pillar Point, Strait    4                              [*********[********]
Cantilever Pier, SJI    6      [*******[******]
Fidalgo Head, NPS       7                    [******[*****]
                             +---------+---------+---------+---------+---------+---------+
                            10.       20.       30.       40.       50.       60.       70.
```

Total Animal Count

```
Site, Region           # of   POOLED ST. DEV. =      0.435
                     Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait    6          [*************[************]
Pillar Point, Strait    4                [***************[***************]
Cantilever Pier, SJI    6                    [************[***********]
Fidalgo Head, NPS       7                                      [***********[**********]
                             +---------+---------+---------+---------+---------+---------+
             log10(Na+1)   2.40      2.70      3.00      3.30      3.60      3.90      4.20
                         Na 250       500       999       1994      3980      7942     15848
```

Animal Diversity H'_a

```
Site, Region           # of   POOLED ST. DEV. =      0.506
                     Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait    6                                     [*******[********]
Pillar Point, Strait    4                          [*********[**********]
Cantilever Pier, SJI    6         [********[*******]
Fidalgo Head, NPS       7                  [*******[*******]
                             +---------+---------+---------+---------+---------+---------+
                           0.50      1.00      1.50      2.00      2.50      3.00      3.50
```

Figure 11. **Means of rocky intertidal assemblage parameters (defined in Section 5.2.1) at each site and elevation sampled, summer 1976, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations from analysis of variance. The one-way analysis of variance model (A.3.1) of Appendix A was used, with separate analyses for each assemblage parameter in each elevation stratum. All available samples were used, resulting in varying group sizes and confidence interval lengths. Axis labels for total animal counts are shown in untransformed as well as log transformed units.**

Mid Elevation (0.6m to 0.9m)

Number of Plant Taxa S_p

```
Site, Region           # of    POOLED ST. DEV. =        4.20
                      Samples  +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6                                [*****[*****]
Pillar Point, Strait     6                                         [*****[*****]
Cantilever Pier, SJI     8                     [****[****]
Fidalgo Head, NPS        7         [*****[****]
                               +---------+---------+---------+---------+---------+---------+
                              0.0       6.0      12.0      18.0      24.0      30.0      36.0
```

Number of Animal Taxa S_a

```
Site, Region           # of    POOLED ST. DEV. =        12.1
                      Samples  +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6                                     [**********[*********]
Pillar Point, Strait     6                                      [*********[**********]
Cantilever Pier, SJI     8          [********[********]
Fidalgo Head, NPS        7        [*********[********]
                               +---------+---------+---------+---------+---------+---------+
                              10.       20.       30.       40.       50.       60.       70.
```

Total Animal Count

```
Site, Region           # of    POOLED ST. DEV. =       0.436
                      Samples  +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6                                     [************[***********]
Pillar Point, Strait     6          [************[***********]
Cantilever Pier, SJI     8                                    [**********[*********]
Fidalgo Head, NPS        7                              [***********[**********]
                               +---------+---------+---------+---------+---------+---------+
     log10(Na+1)              2.70      3.00      3.30      3.60      3.90      4.20      4.50
                     Na        500      999       1994      3980      7942     15848     31622
```

Animal Diversity H'_a

```
Site, Region           # of    POOLED ST. DEV. =        0.603
                      Samples  +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6               [************[************]
Pillar Point, Strait     6                                    [************[***********]
Cantilever Pier, SJI     8                          [**********[**********]
Fidalgo Head, NPS        7      [***********[**********]
                               +---------+---------+---------+---------+---------+---------+
                              0.80      1.20      1.60      2.00      2.40      2.80      3.20
```

Figure 11 (continued)

High Elevation (1.5m to 1.8m)

Number of Plant Taxa S_p

```
Site, Region        # of POOLED ST. DEV. =        8.59
                 Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait   6                  [***********I************I
Pillar Point, Strait   6                       [***********I***********I
Cantilever Pier, SJI   8    [**********I*********I
Fidalgo Head, NPS      6 [***********I***********I
                         +---------+---------+---------+---------+---------+---------+
                       -6.0       0.0       6.0      12.0      18.0      24.0      30.0
```

Number of Animal Taxa S_a

```
Site, Region        # of POOLED ST. DEV. =        12.1
                 Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait   6                      [************I************I
Pillar Point, Strait   6                          [************I************I
Cantilever Pier, SJI   8            [**********I**********I
Fidalgo Head, NPS      6       [************I***********I
                         +---------+---------+---------+---------+---------+---------+
                       -8.0       0.0       8.0      16.0      24.0      32.0      40.0
```

Total Animal Count

```
Site, Region        # of POOLED ST. DEV. =      0.396
                 Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait   6                                      [******I******I
Pillar Point, Strait   6                                       [*****I******I
Cantilever Pier, SJI   8                                [*****I*****I
Fidalgo Head, NPS      6         [*****I******I
                         +---------+---------+---------+---------+---------+---------+
         log10(Na+1)   1.50      2.00      2.50      3.00      3.50      4.00      4.50
                    Na   31        99       315       999      3161      9999     31622
```

Animal Diversity H'_a

```
Site, Region        # of POOLED ST. DEV. =      0.629
                 Samples +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait   6        [************I************I
Pillar Point, Strait   6                        [************I************I
Cantilever Pier, SJI   8                   [***********I**********I
Fidalgo Head, NPS      6                  [*************I************I
                         +---------+---------+---------+---------+---------+---------+
                       0.00      0.40      0.80      1.20      1.60      2.00      2.40
```

Figure 11 (continued)

6.1.2 Population analyses

Patchiness usually precludes the use of analysis of variance or regression analysis for population parameters. However, it was hoped that a few key animals and plants would appear with sufficient regularity in the rocky intertidal to permit such analyses. We considered animal counts, available at all four sites, and plant weights, available at all sites except Fidalgo Head.

A list of taxa to consider was compiled based on frequency of occurrence in samples and biological importance. The plant taxa selected were *Monostroma*, *Enteromorpha linza*, *Ulva*, *Hedophyllum sessile*, *Alaria*, *Fucus*, *Gigartina*, *Iridaea*, *Endocladia muricata*, *Halosaccion glandiforme*, and *Rhodomela larix*. Animals were *Collisella pelta*, *Collisella digitalis*, *Collisella strigatella*, *Lacuna*, *Littorina sitkana*, *Littorina scutulata*, *Katharina*, *Mytilus edulis*, *Chthamalus dalli*, *Balanus cariosus*, *Balanus glandula*, *Idotea wosnesenskii*, gammarid amphipods, *Pagurus hirsutiusculus*, and *Pugettia gracilis*.

The Strait sites were considered first. Weights of the selected plants and counts of animals were plotted versus sampling date and elevation. The plots made it clear that many of these organisms exhibited clear elevation/site preferences. For example, *Littorina scutulata* occurred almost exclusively at the high elevation at Pillar Point. Distributions of other species (for example, *Ulva*, *Collisella pelta*, and *Mytilus edulis*) exhibited so much random patchiness in distribution that means of their counts or weights were generally not significantly different from zero.

The animals and plants which occurred most regularly at each elevation were used in analyses of variance with groups defined by sampling dates. Fewer samples were available at the low elevation than at the mid and high, so we will discuss only the results for the latter two strata. Site, season, and year-to-year differences were examined using orthogonal contrasts (Table 14).

Table 14 suggests many of the same conclusions concerning population parameters as those drawn from analysis of numerical assemblage parameters. There were more significant differences involving spring samples than any other season. Winter was the least changeable season. More highly significant site differences than year-to-year or seasonal differences are shown, but several of these reflect the spring 1976 barnacle recruitment. In addition, site differences may be contributing to or masking year and seasonal differences in some cases since more Tongue Point than Pillar Point samples are averaged into comparisons involving summer, fall, and winter.

In Figure 12 we compare Strait with North Puget Sound results. Counts of the barnacles *Chthamalus dalli* and *Balanus glandula* were considered. Limpets and periwinkles were used at the genus level since there were obvious site differences at the species level: *Collisella strigatella* was much more common at Cantilever Pier than Fidalgo Head, *Littorina scutulata* numerous at both these sites but nearly absent at Tongue Point. Errors in plant weight data precluded consideration of any plants.

TABLE 14. CONTRIBUTIONS OF SITE, YEAR, AND SEASON DIFFERENCES TO VARIABILITY IN STRAIT ROCKY INTERTIDAL POPULATION PARAMETERS

	% OF FACTOR SS[†]						
MID ELEVATION (0.9 METERS)	ALARIA	HALOSACCION[#] GLANDIFORME	LACUNA	KATHA-RINA	BALANUS CARIOSUS	IDOTEA	GAMMARID AMPHIPODS
Site (Tongue vs. Pillar Point):							
Spring 1976	4%	1%	4%	2%	6%	28%	6%
Summer 1976	0	3	5	1	0	6	7
Fall 1976	8	2	2	1	38	1	22
Winter 1977	2	12	3	11	5	8	0
Spring 1977	5	4	4	2	1	0	27*
Year Differences:							
Spring 1976 vs. 1977	4	0	11	12	5	29	7
Summer 1976 vs. 1977	9	0	5	12	18	3	12
Fall 1976 vs. 1977	16	40*	3	29	1	1	12
Winter 1977 vs. 1978	6	17	2	0	0	1	1
Season Differences:							
Spring vs. Summer	1	8	54*	30	5	20	1
Fall vs. Winter	6	1	5	0	13	3	2
Spring/Summer vs. Fall/Winter	39	12	2	0	8	0	3
	100%	100%	100%	100%	100%	100%	100%
HIGH ELEVATION (1.8 METERS)	GIGAR-TINA	ENDOCLADIA MURICATA	COLLISELLA DIGITALIS	COLLISELLA STRIGATELLA	LITTORINA SITKANA	CHTHAMALUS DALLI	BALANUS GLANDULA
Site (Tongue vs. Pillar Point):							
Spring 1976	10%	18%	15%	3%	13%	51%*	28%*
Summer 1976	0	6	2	0	19	21*	23*
Fall 1976	5	7	41	5	0	0	1
Winter 1977	14	9	7	0	1	3	3
Spring 1977	28	30	7	16	3	8	17*
Year Differences:							
Spring 1976 vs. 1977	20	7	1	0	5	3	2
Summer 1976 vs. 1977	9	15	5	49*	13	3	6
Fall 1976 vs. 1977	3	0	2	0	6	1	4
Winter 1977 vs. 1978	3	0	0	8	0	0	0
Season Differences:							
Spring vs. Summer	0	1	12	0	5	0	0
Fall vs. Winter	0	1	6	18	1	0	0
Spring/Summer vs. Fall/Winter	8	6	2	1	33	10	16*
	100%	100%	100%	100%	100%	100%	100%

[†] The Factor SS represents the fraction of the total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

[#] The population parameters considered in this analysis are $\log_{10}$(weight + 1) for the plants (Alaria, Gigartina, Halosaccion glandiforme, and Endocladia muricata) and $\log_{10}$(count + 1) for the animals.

[*] Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for a parameter at one elevation but not another because the overall significance of the Factor SS is higher in the first case than in the second.

Collisella

```
                              POOLED ST. DEV. =        0.812
Site, Region          # of    INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
                    Samples   (BASED ON POOLED STANDARD DEVIATION)
                              +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6                      I***********I**********I
Cantilever Pier, SJI     4           I*************I**************I
Fidalgo Head, NPS        4    I**************I**************I
                              +---------+---------+---------+---------+---------+---------+
      log10(count+1)        0.00      0.60      1.20      1.80      2.40      3.00      3.60
            count            0         3         15        62        250       999       3980
```

Littorina

```
                              POOLED ST. DEV. =        0.841
Site, Region          # of    INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
                    Samples   (BASED ON POOLED STANDARD DEVIATION)
                              +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6      I************I***********I
Cantilever Pier, SJI     4                      I***************I**************I
Fidalgo Head, NPS        4       I**************I**************I
                              +---------+---------+---------+---------+---------+---------+
      log10(count+1)        0.60      1.20      1.80      2.40      3.00      3.60      4.20
            count            3         15        62        250       999       3980      15848
```

Chthamalus dalli

```
                              POOLED ST. DEV. =        0.826
Site, Region          # of    INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
                    Samples   (BASED ON POOLED STANDARD DEVIATION)
                              +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6       I*********I********I
Cantilever Pier, SJI     4                               I***********I**********I
Fidalgo Head, NPS        4            I***********I**********I
                              +---------+---------+---------+---------+---------+---------+
      log10(count+1)        0.00      0.80      1.60      2.40      3.20      4.00      4.80
            count            0         5         39        250       1584      9999      63095
```

Balanus glandula

```
                              POOLED ST. DEV. =        0.959
Site, Region          # of    INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
                    Samples   (BASED ON POOLED STANDARD DEVIATION)
                              +---------+---------+---------+---------+---------+---------+
Tongue Point, Strait     6                      I**********I********I
Cantilever Pier, SJI     4                                   I***********I*************I
Fidalgo Head, NPS        4            I************I*************I
                              +---------+---------+---------+---------+---------+---------+
      log10(count+1)       -0.80      0.00      0.80      1.60      2.40      3.20      4.00
            count            --        0         5         39        250       1584      9999
```

Figure 12. July 1976 means of log transformed counts for selected rocky intertidal animals with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations from analysis of variance. Axis labels are in log units with corresponding counts given below. All available data from high elevations (1.5 m to 1.9 m) were used in the analysis.

Site differences were significant at the 0.05 level for *Chthamalus dalli* but not for the other three taxa. Thus it appears that certain key taxonomic groups are found in predictable large numbers at all rocky sites. Mean values of log counts from the summer 1977 and summer 1978 Cantilever Pier data given by Nyblade (1979b) for these animals provide further confirmation; all lie within the summer 1976 Cantilever Pier confidence intervals except for *Chthamalus dalli* in 1977.

6.1.3 Predictive models

We saw in Table 10 that Tongue Point means at a given elevation and season were generally good predictors of numerical assemblage parameters at that site, elevation, and season in the following year. S_a and H'_a appeared to be particularly stable. Predicting Tongue Point means from Pillar Point data was less successful, and (Table 13 and Figure 11) Strait data on rocky intertidal assemblages were of little use for predicting assemblage parameter values in North Puget Sound. However, the analyses summarized in Table 14 and Figure 12 suggested that parameters of a few key populations might be predictable.

To test site-specific and cross-site prediction of assemblage parameter values within the northern Sound, we compared the 1976 high intertidal Cantilever Pier and Fidalgo Head estimates of Figure 11 with summer 1977 and 1978 Cantilever Pier values computed from Nyblade (1979b) data. The results are summarized in Table 15.

TABLE 15. PREDICTABILITY OF ASSEMBLAGE PARAMETERS FOR HIGH ELEVATIONS, NORTH PUGET SOUND ROCKY INTERTIDAL SITES

			Cantilever Pier					
			Summer 1977			Summer 1978		
				Significance[*]			Significance	
Parameter	1976 Site	Summer 1976 Mean	Mean	*t*-test	Mann-Whitney	Mean	*t*-test	Mann-Whitney
S_p	Cantilever Pier	2.38	0.75	ns	ns	2.75	ns	ns
	Fidalgo Head	1.00		ns	ns		ns	ns
S_a	Cantilever Pier	9.50	5.00	ns	ns	6.00	ns	ns
	Fidalgo Head	6.83		ns	ns		ns	ns
$\log_{10}(N_a+1)$	Cantilever Pier	3.35	2.93	0.0258	0.0508	3.07	ns	ns
	Fidalgo Head	2.22		0.0226	0.0190		0.0193	ns
H'_a	Cantilever Pier	1.19	0.70	ns	ns	1.06	ns	ns
	Fidalgo Head	1.23		ns	ns		ns	ns

[*] Results not significant at the 0.05 level are denoted by ns. The *t*- and Mann-Whitney tests are described in Appendix A. Tests are based on eight samples from Cantilever Pier in summer 1976 (July and early September), four in August 1977, and four in August 1978, and six Fidalgo Head samples from July and August 1976.

Table 15 indicates no significant changes in species richness or diversity. However, both Cantilever Pier and Fidalgo Head means of $\log_{10}(N_a+1)$ in 1976 were significantly different from the 1977 Cantilever Pier value. In terms of counts, the indicated difference at Cantilever Pier translates into a decrease from 2,238 animals per 0.25 m^2 quadrat to 850 animals per quadrat. The 1976 Fidalgo Head mean represents 165 animals per quadrat. This Fidalgo Head value also differs from the 1978 Cantilever Pier value of 1,174 animals per 0.25 m^2. As in the Strait, animal numbers appear to be less predictable than species richness or diversity, and cross-site prediction is less successful than site-specific prediction.

Apparent predictability of either assemblage or population parameters can be evaluated more fully by considering the power (probability of detecting a specified difference) of the statistical tests being used. Powers of the two-sample t- and Mann-Whitney tests are relatively comparable, and that of the t-test is easily obtained as discussed in Appendix A.

In Table 16 we tabulate detectable percent changes in assemblage parameter means as a function of numbers of replicates. We present changes which we would have a 50 percent or 90 percent chance of detecting given that we require the probability of incorrectly stating a change has occurred to be 5 percent or less.

Transformed animal counts and, at the lower elevations, plant weights have the smallest percent changes with a high probability of detection. Hence it is not surprising that many of the significant differences found in our analyses were in these parameters. At the high elevation large replicate variability precludes reliable detection of change in any of the parameters except $\log_{10}(N_a+1)$. Changes in plant diversity H'_p cannot be dependably detected at any elevation.

A similar tabulation of detectable percent changes in population parameters (log transformed animal counts and plant weights) is presented in Table 17. This table indicates that patchiness of almost all plant and animal species makes it virtually impossible to reliably detect population changes even with considerably higher levels of replication than those used in the WDOE and MESA studies.

Plant weights are particularly unpredictable. Even using a one-sided test with $n_1 = n_2 = 25$ the smallest change detectable with 90 percent probability is a 60 percent change in $\log_{10}$(weight + 1) for *Alaria* at the low elevation. Translated from log weight into grams, this implies a decrease to 4 g or an increase to 878 g from a value of 68 g per 0.25 m^2 quadrat.

We fare better with animals, particularly in the relatively simple high intertidal community. The barnacles *Chthamalus dalli* and *Balanus glandula* are good species in terms of change detection. Limpets occur with greatest regularity. We see that lumping to genus level increases the mean value and decreases the variance, with the genus *Collisella* being the most predictable animal taxon. Similarly among the periwinkles, smaller changes

TABLE 16. DETECTABLE PERCENT CHANGES IN ROCKY INTERTIDAL ASSEMBLAGE PARAMETERS

Site and Elevation	Parameter§	Probability of Detection* 0.9				Probability of Detection 0.5			
		$n_1=n_2=4$	$n_1=8, n_2=4$	$n_1=n_2=15$	$n_1=n_2=25$	$n_1=n_2=4$	$n_1=8, n_2=4$	$n_1=n_2=15$	$n_1=n_2=25$
Tongue Point† 0.0 m	S_p	77%(65%)	61%(53%)	35%(30%)	26%(24%)	46%(36%)	37%(30%)	21%(17%)	16%(13%)
	S_a	62 (53)	50 (44)	28 (25)	21 (19)	37 (30)	30 (24)	17 (14)	13 (11)
	$\log_{10}(N_a+1)$	39 (34)	31 (27)	18 (16)	14 (12)	24 (19)	19 (15)	11 (9)	8 (7)
	$\log_{10}(W_p+1)$	36 (30)	29 (25)	16 (14)	12 (11)	21 (17)	17 (14)	10 (8)	8 (6)
	H'_a	36 (31)	29 (25)	17 (15)	13 (11)	22 (17)	18 (14)	10 (8)	8 (6)
	H'_p	244(207)	194(170)	110 (97)	84 (75)	146(116)	117 (95)	66 (55)	51 (42)
Tongue Point 0.9 m	S_p	94 (80)	75 (66)	43 (38)	32 (29)	56 (45)	45 (37)	26 (21)	20 (16)
	S_a	96 (82)	77 (67)	44 (38)	33 (30)	58 (46)	46 (38)	26 (22)	20 (17)
	$\log_{10}(N_a+1)$	35 (30)	28 (24)	16 (14)	12 (11)	21 (17)	17 (14)	9 (8)	7 (6)
	$\log_{10}(W_p+1)$	63 (54)	50 (44)	29 (25)	22 (19)	38 (30)	30 (25)	17 (14)	13 (11)
	H'_a	118(100)	94 (82)	53 (47)	40 (36)	70 (56)	57 (46)	32 (27)	25 (20)
	H'_p	166(142)	133(116)	75 (66)	57 (51)	100 (79)	80 (65)	45 (38)	35 (29)
Tongue Point 1.8 m	S_p	168(143)	134(117)	76 (67)	58 (52)	101 (80)	81 (66)	46 (38)	35 (29)
	S_a	130(111)	104 (91)	59 (52)	45 (40)	78 (62)	63 (51)	35 (29)	27 (23)
	$\log_{10}(N_a+1)$	26 (22)	21 (18)	12 (10)	9 (8)	16 (12)	13 (10)	7 (6)	5 (5)
	$\log_{10}(W_p+1)$	140(119)	112 (98)	63 (56)	48 (43)	84 (67)	67 (55)	38 (32)	29 (24)
	H'_a	143(123)	115(100)	65 (57)	49 (44)	86 (68)	69 (56)	39 (33)	30 (25)
	H'_p	132(113)	106 (93)	60 (53)	46 (41)	80 (63)	64 (52)	36 (30)	28 (23)
Cantilever Pier‡ high	S_p	224(190)	178(156)	101 (89)	77 (69)	134(106)	107 (88)	61 (51)	47 (39)
	S_a	127(109)	102 (89)	58 (51)	44 (39)	76 (61)	61 (50)	35 (29)	27 (22)
	$\log_{10}(N_a+1)$	21 (18)	17 (15)	10 (8)	7 (7)	13 (10)	10 (8)	6 (5)	4 (4)
	H'_a	76 (65)	61 (53)	34 (30)	26 (23)	46 (36)	37 (30)	21 (17)	16 (13)

§ The numerical assemblage parameters included in this table are defined in Section 5.2.1.

* Probabilities of detection (0.9 in the left half of the table, 0.5 in the right half) are based on the assumption that means of the indicated numerical assemblage parameters are being compared using the two-sample *t*-test of (A.4.1) of Appendix A. The level of the test is assumed to be $\alpha = 0.05$. There are assumed to be n_1 replicates in one sample and n_2 in the other. Detectable percent changes for a two-sided test are tabulated, with values for a one-sided test in parentheses. A parameter with a small detectable percent change is usable for estimating community changes while one for which only large changes are detectable is less useful.

† Values of μ_1 in (A.4.5) are summer 1976 means at Tongue Point, shown in Table 10. Values of σ are pooled standard deviations from the analysis of variance of Figure 10.

‡ Values of μ_1 and σ for Cantilever Pier were obtained from the eight high intertidal samples collected there in summer 1976 and used in the analysis of Table 15.

can be detected at the genus level than in particular species such as *Littorina sitkana*.

It is probable that other ways of lumping species, for example into trophic groups, would also lead to more predictable counts than those of the individual species. However, gross differences in productivity and available food are involved in comparing sites in different geographic areas with widely differing amounts of exposure. The larger such physical site differences, the less likely we are to find comparable counts and weights of groups of organisms.

As with plant weights, the detectable percent changes in animal populations given in Table 17 are in log units and the limits of detection must be transformed back if we want them in counts. For *Collisella*, for example, with eight replicates in both old and new samples there is a 90 percent chance of detecting a change from 48 per 0.25 m^2 if the new value lies outside the interval 11 to 207 and we use a two-sided test.

TABLE 17. DETECTABLE PERCENT CHANGES IN ROCKY INTERTIDAL POPULATION PARAMETERS

Elevation and Taxon	Mean μ_1	S.D. σ	Probability of Detection* 0.9 $n_1=n_2=4$	$n_1=n_2=8$	$n_1=n_2=15$	$n_1=n_2=25$	Probability of Detection 0.5 $n_1=n_2=4$	$n_1=n_2=8$	$n_1=n_2=15$
0.0 meters									
Alaria	1.840	1.290	194%(165%)	123%(108%)	88% (77%)	67%(60%)	116% (80%)	74% (61%)	53% (44%)
Iridaea	0.794	0.882	307 (261)	194 (171)	139 (122)	106 (94)	183 (127)	118 (97)	83 (69)
Gammarid amphipod	2.097	0.506	67 (57)	42 (37)	30 (27)	23 (21)	40 (28)	26 (21)	18 (15)
Pugettia gracilis	0.282	0.626	613 (522)	388 (342)	277 (244)	211 (189)	366 (253)	235 (193)	166 (139)
0.9 meters									
Alaria	1.100	1.050	263 (224)	167 (147)	119 (105)	91 (81)	158 (109)	101 (83)	72 (60)
Halosaccion glandiforme	0.757	0.620	226 (192)	143 (126)	102 (90)	78 (70)	135 (93)	87 (71)	61 (51)
Lacuna	1.182	0.605	141 (120)	90 (79)	64 (56)	49 (44)	84 (58)	54 (45)	38 (32)
Katharina	0.575	0.434	208 (177)	132 (116)	94 (83)	72 (64)	125 (86)	80 (66)	57 (47)
Balanus cariosus	1.931	0.892	127 (109)	81 (71)	58 (51)	44 (39)	76 (53)	49 (40)	35 (29)
Idotea	1.179	0.758	177 (151)	113 (99)	80 (71)	61 (55)	106 (73)	68 (56)	48 (40)
Gammarid amphipod	2.368	0.780	91 (77)	58 (51)	41 (36)	31 (28)	54 (38)	35 (29)	25 (21)
1.8 meters									
Fucus	0.570	0.507	245 (209)	156 (137)	111 (98)	85 (76)	147 (101)	94 (77)	67 (56)
Gigartina	0.631	0.513	224 (191)	142 (125)	102 (89)	77 (69)	134 (93)	86 (71)	61 (51)
Endocladia muricata	0.296	0.470	438 (373)	278 (245)	198 (175)	151 (135)	262 (181)	168 (138)	119 (99)
Collisella	1.692	0.353	58 (49)	37 (32)	26 (23)	20 (18)	34 (24)	22 (18)	16 (13)
Collisella digitalis	1.581	0.363	63 (54)	40 (35)	29 (25)	22 (20)	38 (26)	24 (20)	17 (14)
Collisella strigatella	0.381	0.590	427 (364)	271 (238)	194 (170)	147 (132)	256 (177)	164 (135)	116 (97)
Littorina	2.359	0.643	75 (64)	48 (42)	34 (30)	26 (23)	45 (31)	29 (24)	20 (17)
Littorina sitkana	2.283	0.692	84 (71)	53 (47)	38 (33)	29 (26)	50 (35)	32 (26)	23 (19)
Chthamalus dalli	2.861	0.723	70 (59)	44 (39)	32 (28)	24 (21)	42 (29)	27 (22)	19 (16)
Balanus glandula	2.724	0.630	64 (54)	40 (36)	29 (25)	22 (20)	38 (26)	25 (20)	17 (14)

* Probabilities of detection are based on the assumption that means of $\log_{10}$(weight+1) for plants and $\log_{10}$(count+1) for animals are being compared as in Table 16. Means μ_1 in (A.4.5) are from winter 1977 Tongue and Pillar Point samples. Pooled standard deviations from analysis of variance are used for σ. Detectable percent changes for a two-sided test are tabulated, with values for a one-sided test in parentheses. Plants and animals with small detectable percent changes are useful for estimating community change while those in whose populations only large changes are detectable are less useful.

6.1.4 Summary of the prognosis for assessing changes in community structure at rocky intertidal sites

Similarity among rocky intertidal stations in terms of abundance of 50 major plants and animals was shown by cluster analysis to be 25 percent or more in all cases. However, levels of similarity exceeding 75 percent were almost never found between different sites or elevation strata. Taken together with the population analyses of Section 6.1.2, these results imply that the prognosis for estimating abundance of a particular species at one site from the abundance at another is poor, even for sites as close as Tongue Point and Pillar Point and species as common as *Chthamalus dalli*. Cross-site prediction at the genus level (limpets, periwinkles) appears more promising.

Analysis of numerical assemblage parameters as well as cluster analysis pointed to elevation as the dominant factor in variability in the rocky intertidal habitat. Elevation effects vary among the sites, probably as a function of exposure. Within an elevation stratum, assemblage parameter values are similar at nearby sites, particularly if sampling is done in summer or winter rather than in the more volatile spring and fall transition seasons. However, Strait communities are significantly different from northern Sound communities in the same stratum of elevation, probably as a result of exposure differences.

Analysis of variance pinpointed some seasonal and year-to-year differences, especially in spring and summer data, but for the most part they were less significant than site differences. Shorter term (within season) temporal variability was generally insignificant.

The power calculations of Section 6.1.3 indicate that with the level of replication used in the Baseline Studies Program, the probability of detecting changes of 100 percent or more in log transformed weights of individual plant species is less than a half. Changes in log transformed counts of animal species must generally be 50 percent or more if they are to be reliably detected. The situation is almost as bad for most of the assemblage parameters. More replicates per site/season/elevation are needed to assess which population and assemblage parameters exhibit true and which only apparent year-to-year and/or site-to-site stability in the rocky intertidal habitat.

In spite of the rather low probability of detecting small changes provided by the level of replication used in the baseline program, significant year-to-year as well as site-to-site differences were detected in some rocky intertidal analyses (Tables 10, 11, 14, and 15) under baseline (unperturbed) conditions. Hence even when community changes are detected at historically sampled locations, the changes cannot be automatically attributed to known perturbations such as oil spills. Physical, chemical, and biological as well as statistical analyses are needed to determine causes of observed changes.

6.2 INTERTIDAL SOFT SUBSTRATES

A large number of diverse habitats fall into the general category of intertidal soft substrates. All samples available on File 100 tapes from 15 sites were included in our analyses; 705 different plant and animal taxa were identified in these samples. The sites are listed in Table 5 with their stratified sampling elevations. Starred sites in this table were omitted from our analyses since no 1-mm fraction data were available from them. Locations of all sites are shown in Figure 1. Sampling dates and type of sampling (gradient or stratified) are presented in Table 1.

Sites in Table 1 are arranged according to the habitats they were chosen to represent (gravel, sand, mud). The "gravel" category includes sites that were classified as "mixed" or "mixed fine" in some reports. Smith and Webber (1978) classify the Guemes Island site as "pebble-gravel" while Gardner (1978) calls it "mixed fine," for example. Gardner also applies this label to Deadman Bay and Webb Camp, while Nyblade (1977) calls these sites "exposed gravel" and "protected gravel," respectively.

The difficulty of appropriately categorizing some sites according to habitat is increased by dramatic changes in substrate character with elevation. For example, Jamestown in reality consists of a high intertidal region of sandy gravel, a mid region of fine sand (mud), and a region of medium sand at MLLW.

As noted in Section 4, the data base contains little usable information on exposure. Therefore we have not attempted to tabulate detailed exposure ratings for the sites, but it should be noted that our analyses indicate that exposure may well be more crucial than sediment size in defining habitats. In the following discussions of analysis results, we attempt to fill some gaps and resolve discrepancies in habitat characterizations of the soft-bottom intertidal sites. Our general approach to the analysis of soft substrate intertidal habitats is the same as for rock.

6.2.1 Community analyses

Comparison of all soft substrate sites and elevations:

To obtain an overall concept of the relationships among sites and elevations, cluster analysis was applied to two major subsets of the data for soft substrates, the first from the summers of 1976 through 1978 (Figure 13) and the second winter data from 1975 through 1978 (Figure 14).

We have labelled the major groups I, II, III, IV, and V in the figures. Relationships among these groups are weak. Separation among them appears to be related more to degree of exposure than to geographic position, elevation, or substrate type. Group I, the largest group in both seasons, includes primarily protected or only moderately exposed sites. Almost all of the group II and III sites are exposed. The substantial differences between groups II and III probably relate to degree of exposure.

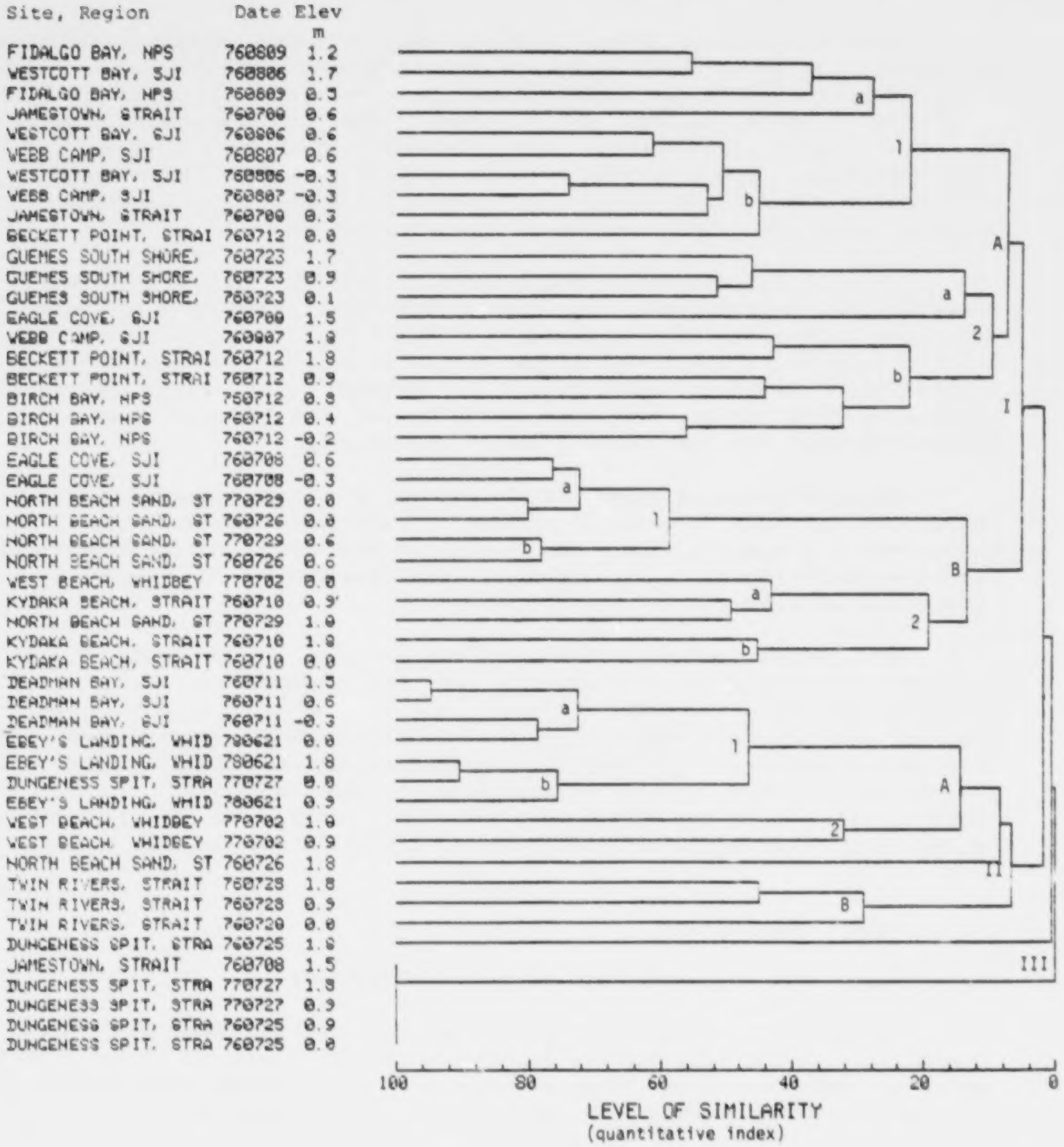


Figure 13. Summer soft substrate intertidal station relationships. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-2.

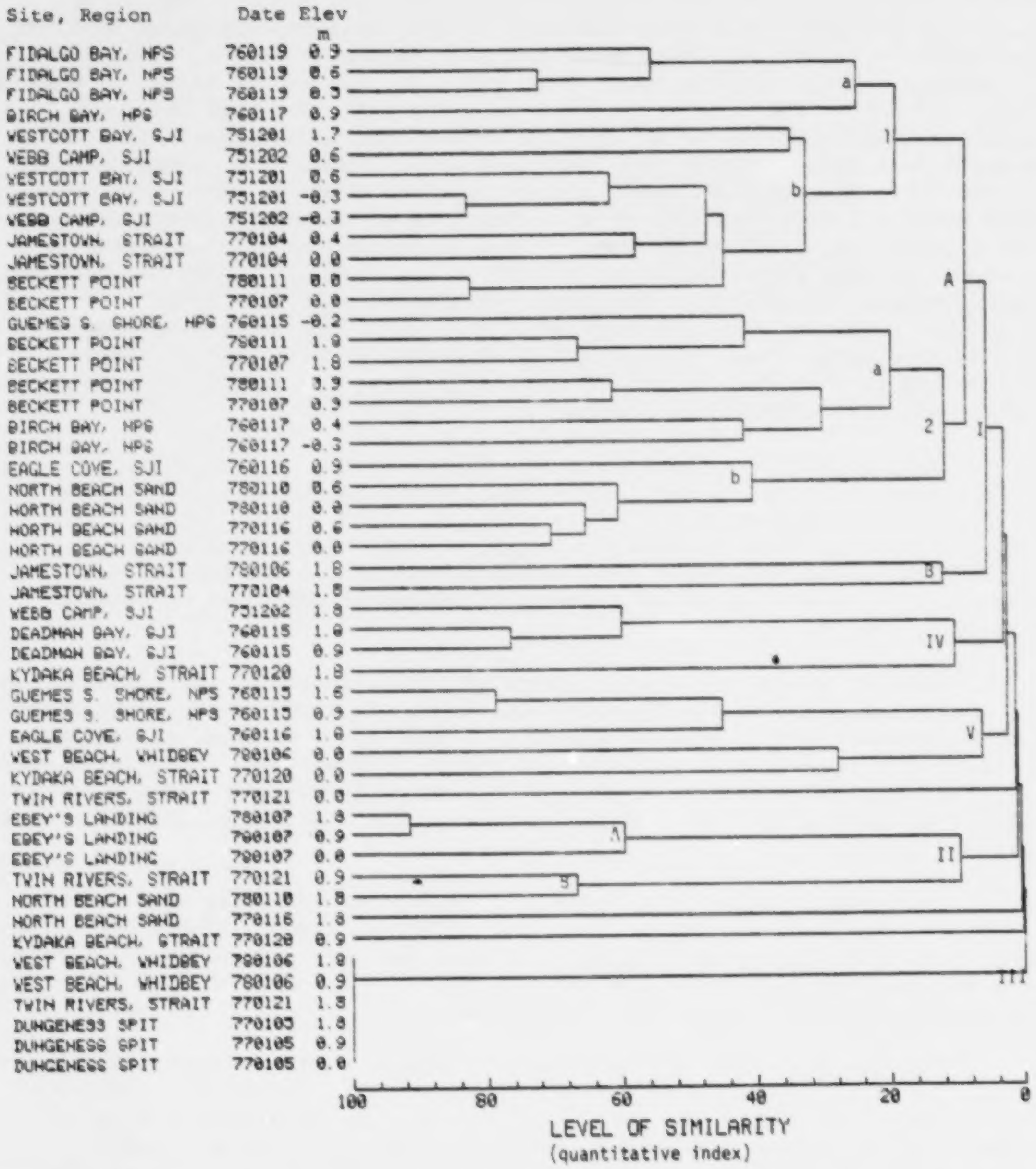


Figure 14. **Winter soft substrate intertidal station relationships. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-2.**

Generally, levels of similarity among stations within the major groups are low. However, internal similarity is total (100 percent) among the group III stations, from Dungeness Spit in both seasons, the upper level at Jamestown in summer, and West Beach and Twin Rivers in winter. West Beach is on Whidbey Island, and the other three sites are all in the Strait of Juan de Fuca. No NPS or SJI site is included in group III. The high level of indicated similarity is an artifact of conventions in data analysis. The samples from these sites either contained only oligochaetes, nematodes, or unidentified gammarid amphipods, or contained no animals. The three general taxa mentioned were excluded by data screening of taxonomic codes from use in the cluster analyses because they are too unspecific to be discriminative. However, so that sites would not be lost to the analysis, those at which no taxa survived the data screening were assigned an arbitrary artificial taxonomic code, "none of the included taxa", which was subsequently used in cluster analysis. Thus, all group III stations had that code in common and showed 100 percent similarity. This site grouping undoubtedly comprises the sites with the harshest environment.

Substrate type appears to be the factor second in importance in determining groupings in the dendrograms. Muddy substrates, for instance, only occur in subgroup (limb) A-1 of group I. Group I also includes many sand sites. The only gravel sites in group I are those alternatively categorized as "mixed fine"; i.e., their sediments include sand or mud. In contrast, various mixtures of gravel predominate at the sites comprising groups II and III.

In both summer and winter, pairs of stations showing the highest level of similarity were usually from the same site. In a few cases (North Beach, summer; Beckett Point, winter) they were a year apart in time, indicating considerable year-to-year stability in species composition. Site differences usually dominated elevation differences, with subgroups often including all elevations at a given site. Finer details of the dendrograms differ between the two seasons.

In summer (Figure 13), group II includes approximately equal numbers of Strait, Whidbey, and SJI stations but no NPS stations. Limb II-B includes only Twin Rivers stations, whereas limb II-A represents five locations from the Strait, Whidbey Island, and San Juan Island. Within limb II-A, the major dichotomy segregates sand from gravel sites.

The primary dichotomy in group I in summer divides exposed sand sites (limb I-B) from more protected sand, mud, and mixed fine sites (limb I-A). Within limb I-B, Kydaka and West Beach stations are separated from North Beach and Eagle Cove. Elevations range from -0.3 m to 1.8 m. Within limb I-A, limb I-A-1 sites comprise the most protected mud and mixed fine sites. Limb I-A-1-a includes mid to high elevations and limb I-A-1-b low to mid elevations. Limb I-A-2 includes somewhat less protected sand and sandy gravel stations; elevation, ranging from -0.2 m to 1.8 m, is not an important consideration.

In the winter analysis (Figure 14) the number of major dichotomies increased from three to five and there were more individual stations that did not fall into any of the major groups than were apparent in the summer analysis. Groups IV and V include sand and gravel sites from all geographical areas and exposure classifications as well as all elevation strata. The small number of species which stations forming these groups have in common are mostly isopods (*Gnorimosphaeroma*, *Exosphaeroma*) or amphipods (*Eohaustorius*, *Paraphoxus*). The increased number of major dichotomies may be a reflection of a sharpening of differences by the rigors of winter. However, the probability is just as high that it is an artifact of sampling variability in response to typically lower abundance and numbers of species normally encountered in winter surveys.

In winter the major dichotomy in group I separates two high-elevation Jamestown samples a year apart (limb I-B) from limb I-A samples representing protected or moderately exposed sites. Limb I-A-1 includes only protected sites, with limb I-A-1-a representing NPS and limb I-A-1-b SJI and Strait sites. Limb I-A-2-a includes four stations from Beckett Point in the Strait and three NPS stations. Low to mid elevation samples from the moderately exposed SJI and Strait sand sites make up limb I-A-2-b. Group II, smaller in winter than in summer, has all Ebey's Landing stations on limb II-A and one station each from North Beach and Twin Rivers on limb II-B.

Comparison of less exposed soft substrate sites at mid elevations:

We next partitioned out elevation and extreme exposure effects to delineate the effects of site, season, substrate, and moderate differences in exposure more clearly. We used data from all seasons for the middle level at the less exposed soft substrate sites to produce the dendrogram of Figure 15. Group I in this figure is characterized by protected mud, sand, and mixed fine sites. Group II is characterized by moderately exposed sites with sand. Group III consists of two anomalous NPS stations.

Within group I, segregation by substrate, site, and region is strong, especially within limb I-A. For example, SJI sites cluster together, and Fidalgo Bay stations form subgroup I-A-1-a. The level of similarity within the subgroups of this limb is high. Within group II, the more exposed sand sites (North Beach and Eagle Cove) are primarily represented in limb II-B, whereas more protected mixed sites (Guemes Island and Beckett Point) are in limb II-A. Segregation of stations at a site on the basis of season is common in both groups I and II.

The analyses were further refined by partitioning summer from winter data (Figures 16 and 17). The basic patterns are the same. The major dichotomies are based on factors related to the degree of wave exposure, and groups displaying the highest internal similarity comprise stations from the same location. Two good examples in the summer analysis of Figure 16 are limb I-A-1 (Fidalgo Bay) and I-A-2-a (Westcott Bay and Webb Camp, in Westcott Bay). The clearest segregation by site appears in the winter analysis (Figure 17), probably because exposure patterns are more clearly defined in winter, and juveniles of most nonresident species that confuse distribution patterns in summer have been eliminated by exposure factors.

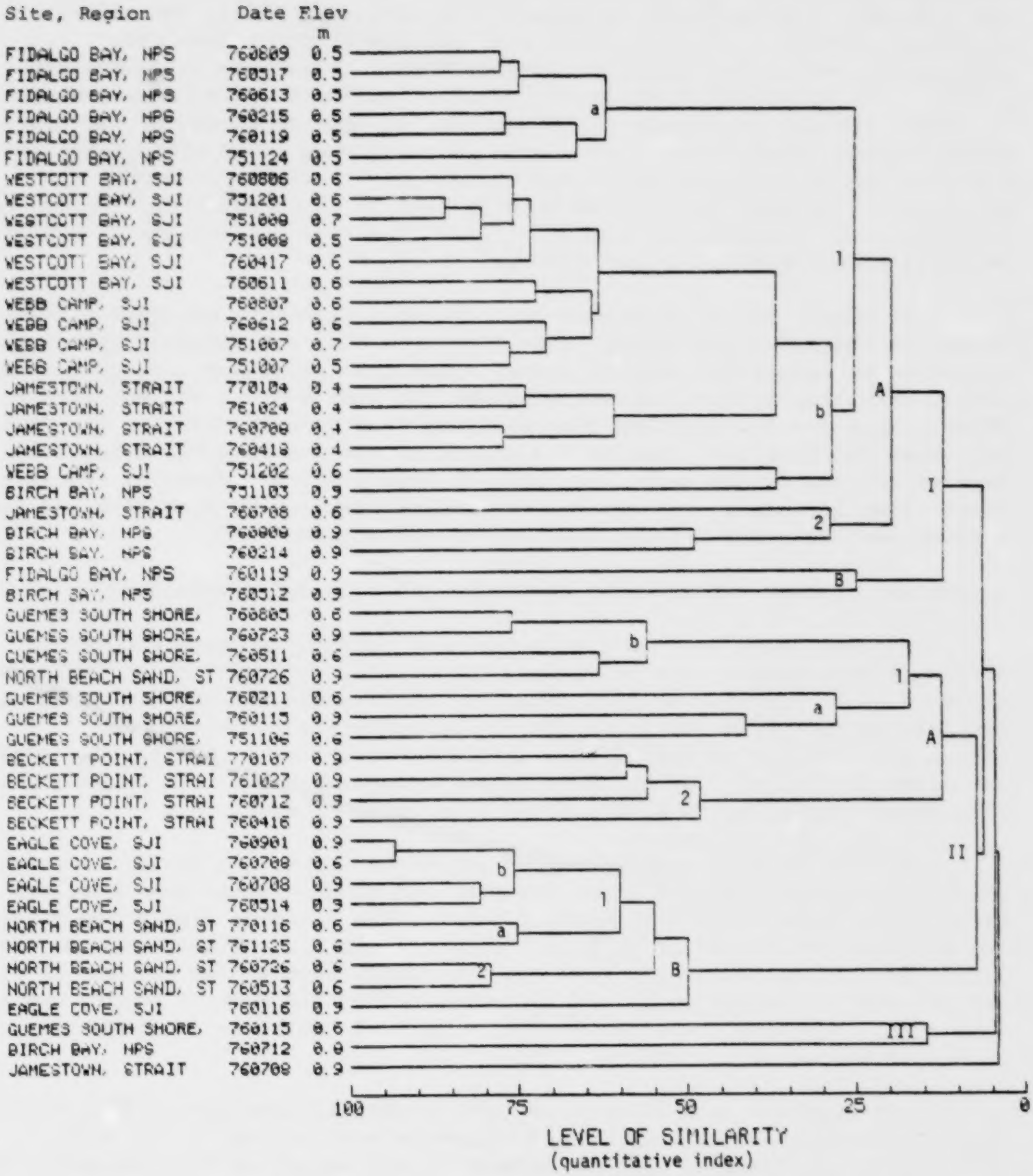


Figure 15. **Relationships among less exposed soft substrate intertidal stations, mid elevations. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-2.**

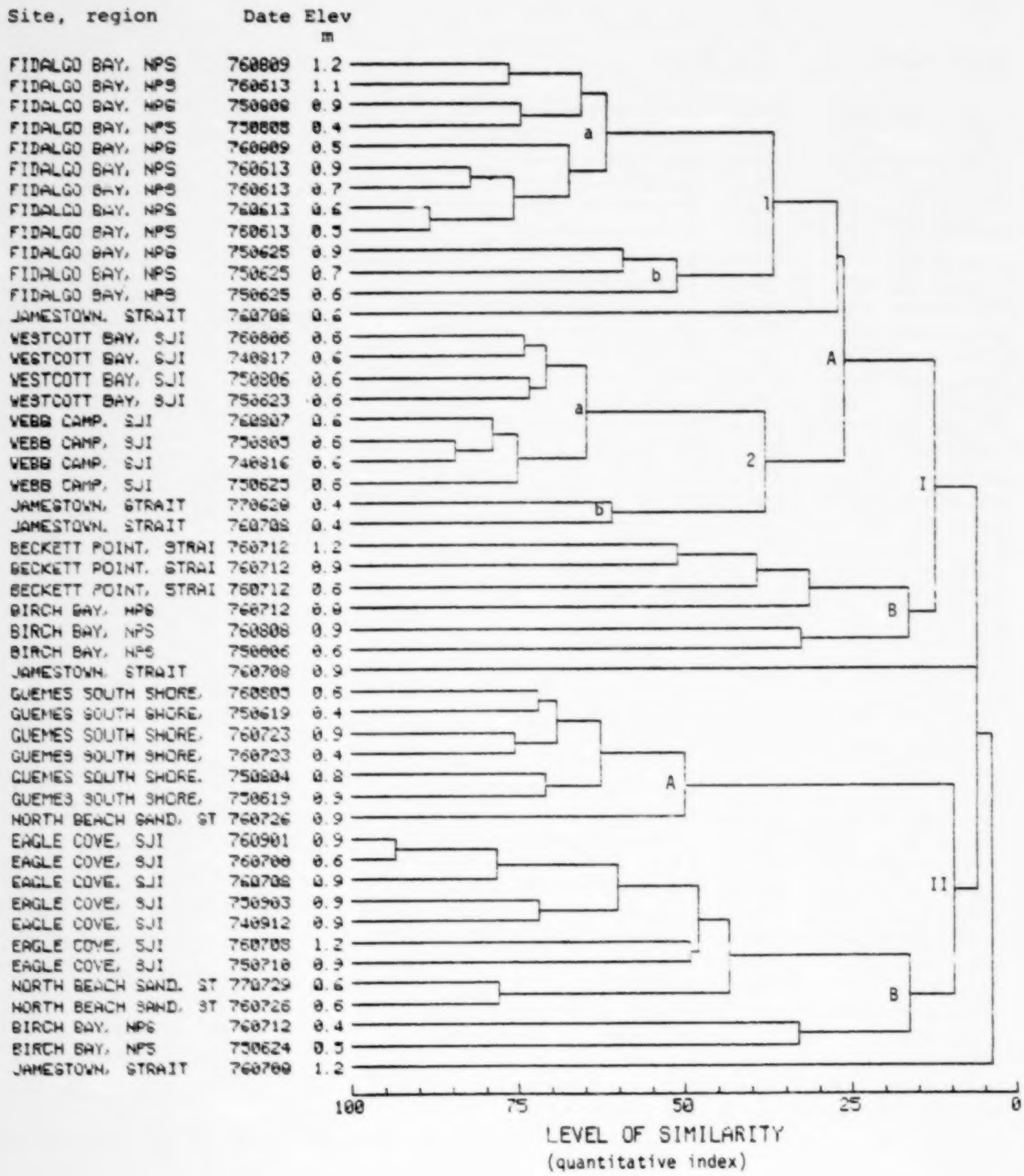


Figure 16. Summer relationships among less exposed soft substrate intertidal stations, mid elevations. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-2.

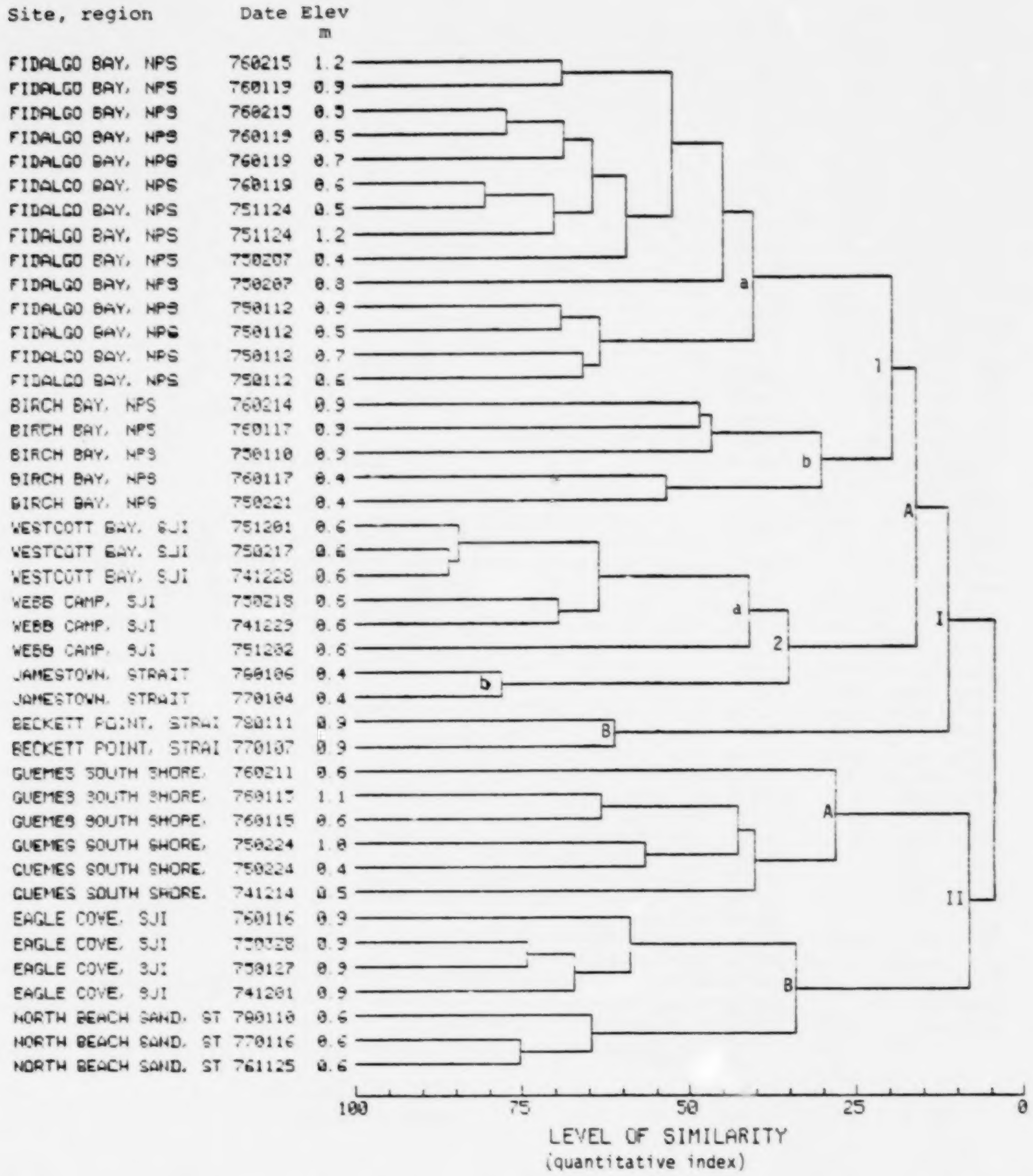


Figure 17. Winter relationships among less exposed soft substrate intertidal stations, mid elevations. Similarity between stations is defined by (A.5.1) of Appendix A in terms of relative abundance of the 50 plant and animal species or groups marked with stars in Table B-2.

General considerations concerning numerical assemblage parameters:

The cluster analyses described above provided guidelines for more quantitative analyses of the soft-bottom intertidal sites. Because exposure was the dominant factor in defining groups in the cluster analyses, we considered exposed and protected soft-bottom sites separately. All assemblage parameters were calculated separately for each $0.05\ m^2$ x 15 cm core. We did not perform detailed analyses of the "live sieve" samples because of numerous problems in the live sieve data (see Section 4.2).

Plants were not found in intertidal samples from exposed soft substrate sites, but some, for example eelgrass, play an important role in more protected communities. Nevertheless 1,084 of the 1,303 samples included in our analyses of protected soft substrate intertidal sites contained no plants, and only 22 contained four or more different plant species. Histograms of S_p at sites where plants were found are shown in Figure 18. Because plants occurred in such a small fraction of the samples, plant assemblage parameters could not be examined using analysis of variance or regression techniques. Therefore, we restricted our consideration to animal richness S_a and transformed total count $\log_{10}(N_a+1)$ in most soft substrate assemblage parameter analyses. Animal diversity H'_a was also considered at protected sites; this parameter was generally not significantly greater than zero at exposed sites. At NPS sites where it was consistently available, $\log_{10}(W_a+1)$ was also considered.

Analysis of variance at exposed soft substrate sites:

Evaluation of exposure, substrate, region, and elevation effects at exposed sand and gravel sites, summer: The six Whidbey and Strait sites which clustered in or near the "most exposed" groups II and III of Figure 14 were considered first. Five summer samples from each of the three elevation strata were available at each of these sites. Summer 1977 data from Dungeness Spit, Kydaka Beach, and North Beach in the Strait and West Beach on Whidbey were used. No summer 1977 data were available on tape for Twin Rivers in the Strait or Ebey's Landing on Whidbey, so 1976 data were used for the former and 1978 for the latter.

Means for S_a and $\log_{10}(N_a+1)$ at each site and elevation are shown in Figure 19. A set of orthogonal contrasts (Table 18) was used to quantify differences, some of which are evident in Figure 19, among the groups in the one-way analysis of variance. The overall F statistic (A.3.5) for each assemblage parameter was highly significant (0.001). It was most significant for S_a, which explains why 4 percent of the Factor SS is significant at the 0.001 level for S_a but not for $\log_{10}(N_a+1)$ in Table 18.

The first four contrasts indicate highly significant contributions to variability due to differences between sand and gravel substrates and high versus moderate wave energy. However, the possibility of confounding of effects is present. For example, since Twin Rivers and Ebey's Landing data are from different years, year effects could be contributing to the "substrate" contrasts. Site differences other than sediment composition may also be influencing the results. For instance, cluster analyses and sediment

```
MIDDLE OF    NUMBER OF      Jamestown, Strait
INTERVAL     OBSERVATIONS
     0.        37     *************************************
     1.        14     **************
     2.         8     ********
     3.         4     ****
     4.         0
     5.         2     **
     6.         2     **
     7.         1     *
     8.         0
     9.         0
    10.         0
    11.         1     *
    12.         0
    13.         0
    14.         0
    15.         0
    16.         0
    17.         0
    18.         1     *

EACH * REPRESENTS    2 OBSERVATIONS

MIDDLE OF    NUMBER OF      Beckett Point, Strait
INTERVAL     OBSERVATIONS
     0.        55     ****************************
     1.         3     **
     2.         2     *
     3.         2     *
     4.         3     **
     5.         1     *
     6.         0
     7.         1     *
     8.         0
     9.         2     *

EACH * REPRESENTS    2 OBSERVATIONS

MIDDLE OF    NUMBER OF      Westcott Bay, SJI
INTERVAL     OBSERVATIONS
     0.        56     ****************************
     1.        13     *******
     2.         7     ****
     3.         5     ***
     4.         1     *
     5.         1     *
```

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EACH * REPRESENTS    2 OBSERVATIONS

MIDDLE OF    NUMBER OF      Webb Camp, SJI
INTERVAL     OBSERVATIONS
     0.        72     ************************************
     1.        10     *****
     2.         2     *
     3.         3     **
     4.         3     **
     5.         1     *
     6.         0
     7.         0
     8.         1     *

EACH * REPRESENTS    5 OBSERVATIONS

MIDDLE OF    NUMBER OF      Fidalgo Bay, NPS
INTERVAL     OBSERVATIONS
     0.       127     **************************
     1.        18     ****
     2.        31     *******
     3.         2     *

EACH * REPRESENTS    5 OBSERVATIONS

MIDDLE OF    NUMBER OF      Birch Bay, NPS
INTERVAL     OBSERVATIONS
     0.       144     *****************************
     1.        29     ******
     2.         3     *
     3.         0
     4.         1     *

EACH * REPRESENTS    5 OBSERVATIONS

MIDDLE OF    NUMBER OF      Guemes Island, NPS
INTERVAL     OBSERVATIONS
     0.       145     *****************************
     1.        32     *******
     2.         6     **
     3.         3     *
```

Figure 18. Histograms of number of plant taxa S_p at protected soft substrate sites where plants were found. The number of observations (samples) in which S_p (number of plant taxa) had the "middle of interval" value is plotted.

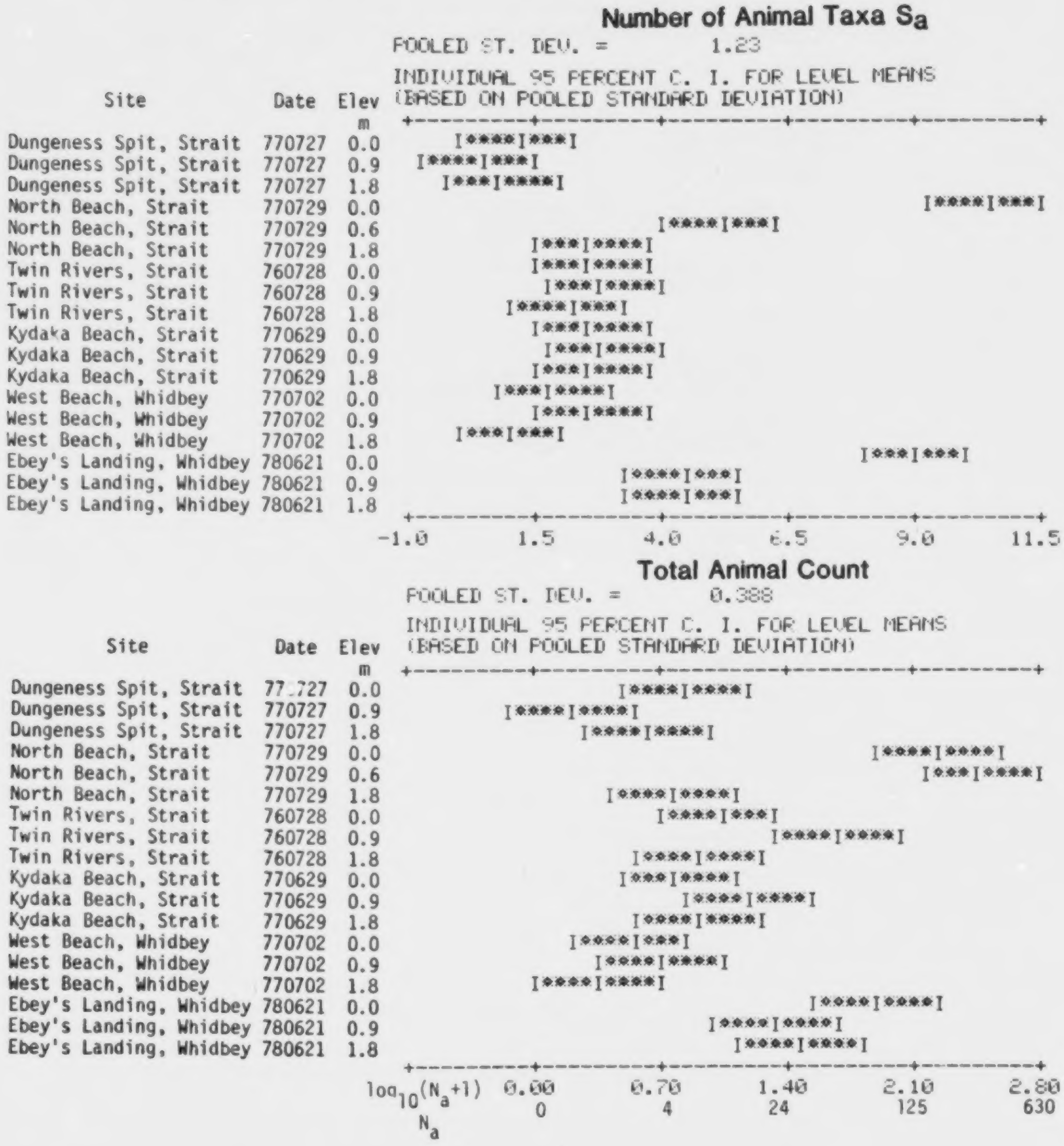


Figure 19. Group means from analysis of variance of numerical assemblage parameters (defined in Section 5.2.1) from exposed sand and gravel intertidal sites, summer, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations. The one-way analysis of variance model (A.3.1) of Appendix A with $n_i = 5$ in each group was used. Axis labels for total animal count are shown in untransformed as well as log transformed units.

TABLE 18. CONTRIBUTIONS OF EXPOSURE, SUBSTRATE, REGION, AND ELEVATION DIFFERENCES TO VARIABILITY IN SUMMER ASSEMBLAGE PARAMETERS AT EXPOSED SAND AND GRAVEL INTERTIDAL SITES

	% of Factor SS†	
	S_a#	$\log_{10}(N_a+1)$
AVERAGES OVER ALL ELEVATIONS TO COMPARE:		
Exposure:		
L_1 high vs. moderate wave energy gravel (?) (Dungeness Spit vs. Twin Rivers)	4%*	9%*
L_2 high vs. moderate wave energy sand (?) (Kydaka Beach vs. North Beach)	15 *	16 *
Substrate:		
L_3 Strait sand vs. gravel (?) (Kydaka Beach/North Beach average vs. Dungeness Spit/Twin Rivers average)	18 *	12 *
L_4 Whidbey sand vs. gravel (?) (West Beach vs. Ebey's Landing)	21 *	24 *
Geographic area:		
L_5 Strait vs. Whidbey (?) (average of all four Strait sites vs. average of both Whidbey sites)	2	1
ELEVATION:		
L_6 Dungeness Spit mid vs. high elevation	0	1
L_7 Dungeness Spit low vs. (mid + high)	0	2
L_8 North Beach mid vs. high	3	22 *
L_9 North Beach low vs. (mid + high)	24 *	4
L_{10} Twin Rivers mid vs. high	0	4
L_{11} Twin Rivers low vs. (mid + high)	0	1
L_{12} Kydaka Beach mid vs. high	0	1
L_{13} Kydaka Beach low vs. (mid + high)	0	0
L_{14} West Beach mid vs. high	1	1
L_{15} West Beach low vs. (mid + high)	0	0
L_{16} Ebey's Landing mid vs. high	0	0
L_{17} Ebey's Landing low vs. (mid + high)	12 *	2
	100%	100%

† The Factor SS represents the fraction of the total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

The numerical assemblage parameters S_a (number of animal taxa) and $\log_{10}(N_a+1)$ (log transformed animal count) are defined in Section 5.2.1.

* Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not the other because the overall significance of the Factor SS is higher for the one than for the other.

? Question marks indicate possible confounding of effects; see Section A.3 of Appendix A.

size data indicated that West Beach should probably be classified as a highly exposed mixed sand and gravel site. As noted in Section 4.2.3, sediment composition and beach slope at West Beach varied dramatically during the study. Hence, contrast L_4 may be reflecting exposure rather than substrate differences.

To assess exposure effects, only the Strait sites were considered because the Habitat Codes assigned by Nyblade on the File 100 tapes, unlike those of Webber for the Whidbey sites, agreed fairly well with the site descriptions in Nyblade (1978, 1979a). Kydaka Beach and Dungeness Spit were coded as high wave energy sites, North Beach and Twin Rivers as only moderate wave energy, so Dungeness Spit and Twin Rivers were used to define the "high versus moderate wave energy gravel" contrast and Kydaka and North Beach for the corresponding contrast for sand. However, as with the substrate contrasts, the exposure contrasts may reflect unspecified site characteristics in addition to wave energy, and L_1 may also involve year effects.

There are other possibilities for confounding of effect that cannot be unraveled from the present data set. For example, the Strait versus Whidbey dichotomy L_5 may reflect differences between investigators as well as geographic differences. The design of the studies that resulted in all the Strait data being taken by Nyblade and all the Whidbey data by Webber makes it impossible to determine whether this might be a contributing factor. The effects of investigator bias on the number of taxa identified appear even more likely to be a problem in the earlier WDOE data sets.

Contrasts L_6 through L_{17} measure elevation effects at each site. The only highly significant elevation effects were at North Beach and Ebey's Landing. We see from Figure 19 that the low elevation at both these sites was richer than the higher. At North Beach, total animal count was significantly greater at the low and mid elevations than at the high. No large elevation effects were apparent at other sites, particularly the most exposed.

Exposed sand and gravel sites, winter: We also performed a one-way analysis of variance on winter data from the "most exposed" site group. To eliminate any possible confounding of temporal effects with elevation and site effects of interest, only data taken in January 1978 were used. Thus, Kydaka Beach and Twin Rivers, which were not sampled at that time, were eliminated. The five available samples from each of the three elevation strata at the four remaining sites were included.

Means of S_a and $\log_{10}(N_a+1)$ for the twelve groups thus defined are plotted in Figure 20. As in the summer analysis, the F statistic (A.3.5) indicated highly significant differences among means for both parameters. Contrasts used to pinpoint the factors leading to these differences are presented in Table 19.

It is clear from both Figure 20 and Table 19 that differences among the three elevations at North Beach and between North Beach and the other sites accounted for the largest fraction of the Factor SS. The low elevation at Ebey's Landing was also somewhat anomalous. The low and mid elevations at

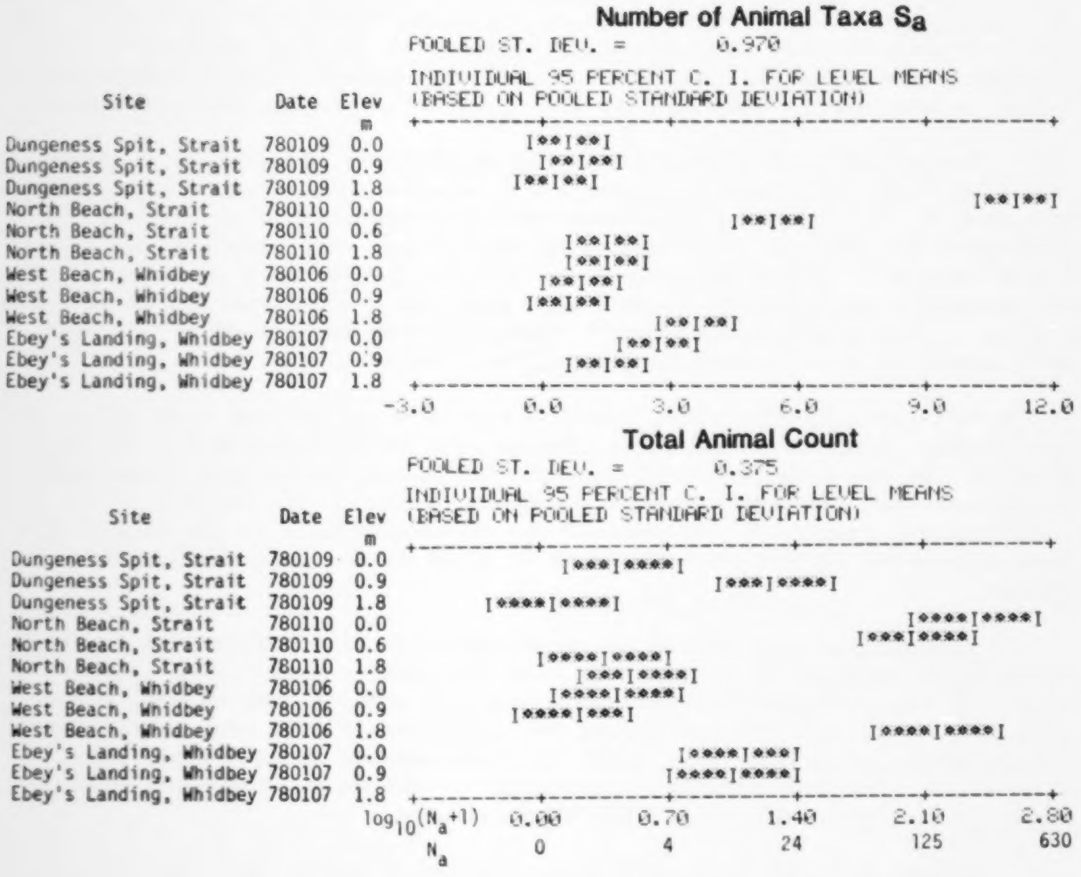


Figure 20. Group means from analysis of variance of numerical assemblage parameters (defined in Section 5.2.1) from exposed sand and gravel intertidal sites, winter, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations. The one-way analysis of variance model (A.3.1) of Appendix A with $n_i = 5$ in each group was used. Axis labels for total animal count are shown in untransformed as well as log transformed units.

TABLE 19. CONTRIBUTIONS OF SITE AND ELEVATION DIFFERENCES TO VARIABILITY IN WINTER ASSEMBLAGE PARAMETERS AT EXPOSED SAND AND GRAVEL SITES

		% of Factor SS†	
		S_a#	$\log_{10}(N_a+1)$
SITE (comparing averages over all elevations):			
L_1	Dungeness Spit vs. North Beach	42%*	20%*
L_2	West Beach vs. Ebey's Landing	3 *	23 *
L_3	Strait vs. Whidbey	6 *	1
ELEVATION:			
L_4	Dungeness Spit low vs. mid elevation	0	5
L_5	North Beach low vs. mid	16 *	1
L_6	West Beach low vs. mid	0	0
L_7	Ebey's Landing low vs. mid	1	8 *
L_8	Dungeness (low + mid) vs. high	0	6 *
L_9	North (low + mid) vs. high	30 *	32 *
L_{10}	West (low + mid) vs. high	0	1
L_{11}	Ebey's (low + mid) vs. high	2	3
		100%	100%

† The Factor SS represents the fraction of the total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

# The numerical assemblage parameters S_a (number of animal taxa) and $\log_{10}(N_a+1)$ (log transformed animal count) are defined in Section 5.2.1.

* Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not the other because the overall significance of the Factor SS is higher for the one than for the other.

North Beach and the low elevation at Ebey's Landing were richer in animals than the other elevations and sites in winter, as was also noted in summer.

Sediment grain size analyses for the winter samples at Ebey's Landing indicated only minimal differences in sediment composition among the three elevations. Summer sediment data indicated the presence of cobble at the low elevation and an increase in the fraction of sand at the others. However, as noted in Section 4.2.3, we cannot determine the statistical significance of these sediment shifts. Sediment size data from North Beach are lacking for both the summer and winter sampling dates, but earlier sediment size analyses indicate that the proportion of gravel at the North Beach site and the variability of this proportion increase with elevation.

In short, it is likely that the "elevation" effects at these sites are at least partially due to substrate characteristics which changed with tidal elevation at most sites. Whatever their causes, the consistency of summer and winter results points to the conclusion that indicated differences are real. However, many of the highly significant differences cannot be adequately explained even when both substrate and elevation are considered.

Dungeness Spit and Ebey's Landing were both defined as gravel habitats and North Beach and West Beach as sand. The analysis of variance results just discussed, like the dendrograms produced by cluster analysis, suggest that the sand-gravel dichotomy may not produce useful habitat definitions for predictive purposes. The sediment composition at all these sites (with the possible exception of the low elevation at North Beach) tends to be a gravel-sand mix that varies with time. In terms of all three assemblage parameters, only the high elevation at North Beach "sand" was as similar to West Beach "sand" as was the species-poor Dungeness Spit "gravel" site.

To focus on site and year effects and eliminate the anomalous lower elevations at North Beach and Ebey's Landing as well as any more subtle elevation differences, analyses were done on all winter upper intertidal data from the sites previously considered and the exposed SJI sand (Eagle Cove) and gravel (Deadman Bay) sites. Of the 80 samples included in this analysis, 30 proved to be abiotic. Therefore, the statistical assumptions of the analysis of variance model were certainly violated, and confidence intervals and significance tests were not meaningful. The means indicated fairly high year-to-year and site-to-site similarity except that the SJI sites, particularly Deadman Bay, supported a great many more animal taxa and individuals than any of the others. Eagle Cove appeared to lie between Deadman Bay and the other sites in richness. According to Nyblade, richness at the SJI sites may be inflated by washed-in nonresident species.

Contributions of site, season, year, and elevation differences to variability, moderately exposed sand and gravel sites: To further investigate differences between the San Juan Island sites and the others several additional analyses were performed. Contributions of elevational, year-to-year, between-season, and within-season differences to variability were also examined in these analyses.

Eagle Cove and North Beach data at all elevations from the spring and summer of 1976 and one winter data set from each of these sites were included in one-way analyses of variance. Five replicates per elevation obtained by stratified sampling were available at each of the selected dates except at Eagle Cove in July 1976 where samples from -0.3 m to +0.3 m constituted the five low elevation replicates; 0.6 m to 1.2 m, the mid; and 1.5 m to 2.1 m, the high. The use of these gradient samples tended to increase the within-group variability slightly on this date; the maximum F ratio statistic (A.3.10) for $\log_{10}(N_a+1)$ indicated differences in group variances significant at the 5 percent level.

Groups and their means are shown in Figure 21. Contrasts computed from these means (Table 20) quantify the patterns evident in the figure. Clearly, elevation effects dominate at both of these sites. Both S_a and N_a decrease with increasing elevation. Some significant differences between the sites at all seasons are apparent in number of animals though not in number of taxa. A winter decrease in number of animals is indicated.

A similar analysis was performed on summer and winter data from Ebey's Landing (1978) and Deadman Bay (1975). As at Eagle Cove and North Beach, elevation differences accounted for more than half of the variability in numbers of taxa and individuals. Animal counts were significantly higher at Deadman Bay, with this difference accounting for 37 percent of the variability. Seasonal differences in animal counts were minimal, but the number of taxa at Ebey's Landing was significantly higher in summer than in winter.

A separate analysis of the bi-monthly mid intertidal data taken at Deadman Bay between July 1974 and May 1976 revealed significant year-to-year differences in animal counts for July and March data. Months within the same season did not differ greatly except possibly in spring, but large differences were indicated between spring and summer and for spring/summer versus fall/winter. S_a varied less with time than $\log_{10}(N_a+1)$. Significant spring versus summer differences were also indicated at the low elevation at North Beach by an analysis of the quarterly data at that site and elevation.

Site and year effects, exposed upper intertidal sand and gravel habitats, summer: A final analysis of upper intertidal summer data from the exposed sand and gravel sites was conducted. Deadman Bay was omitted from this analysis because it had already been found to have much larger numbers of animals than any of the other exposed sites, but Eagle Cove was included. Five samples from each site, date, and elevation stratum were used. The F-ratio (A.3.10) indicated no significant variance heterogeneity in S_a or $\log_{10}(N_a+1)$ among the groups included in this analysis.

The overall F-statistic (A.3.5) indicated significant between-group differences in S_a at the 1 percent and in $\log_{10}(N_a+1)$ at the 5 percent level. As expected from the results already presented, Ebey's Landing data was the primary contributor to the between-group differences in this analysis. The contrast between the 1978 summer mean at Ebey's Landing and the average of the other group means (all but one, unfortunately, representing previous years as well as other sites) accounted for a highly

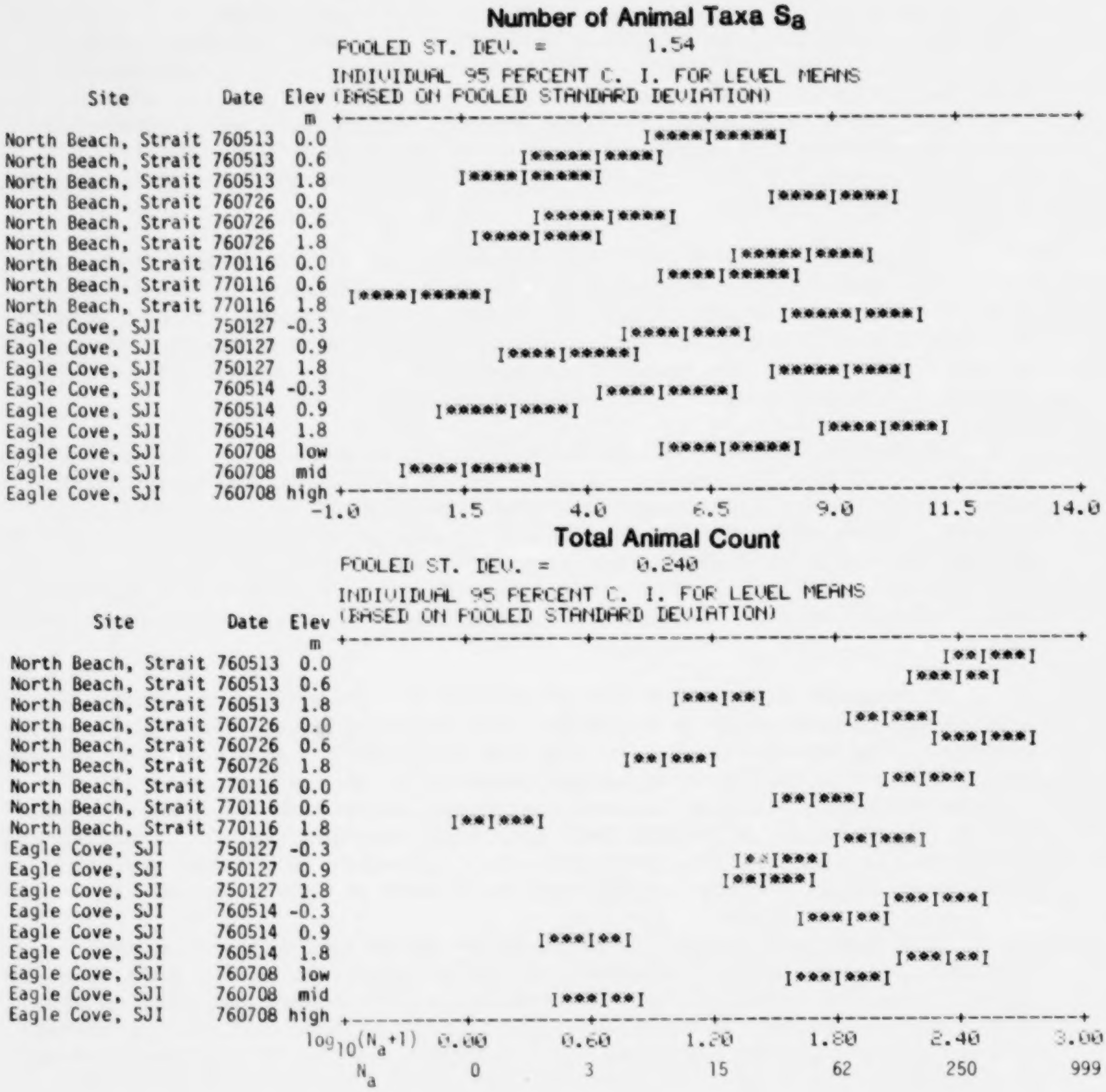


Figure 21. Group means from analysis of variance of numerical assemblage parameters (defined in Section 5.2.1) at moderately exposed sand sites, three seasons and elevations, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations. The one-way analysis of variance model (A.3.1) of Appendix A with $n_i = 5$ in each group was used. Axis labels for total animal count are shown in untransformed as well as log transformed units.

TABLE 20. CONTRIBUTIONS OF SITE, ELEVATION, AND SEASON DIFFERENCES TO ASSEMBLAGE PARAMETER VARIABILITY, MODERATELY EXPOSED SAND SITES

	% of Factor SS †	
	S_a#	$\log_{10}(N_a+1)$
EAGLE COVE VS. NORTH BEACH:		
Spring 1976 low elevation	2%	0%
mid	1	2 *
high	0	3 *
Summer 1976 low	0	0
mid	2	3 *
high	1	1
Winter 1975 vs. winter 1977 low	0	0
mid	0	0
high	3	10 *
SEASON (comparing averages of the two sites):		
Spring vs. summer low	2	1
mid	0	0
high	0	0
(Spring + summer) vs. winter low	0	0
mid	1	4 *
high	0	0
ELEVATION (comparing averages over sites and seasons):		
Low vs. mid	22 *	4 *
(Low + mid) vs. high	66 *	72 *
	100%	100%

[†] The Factor SS represents the fraction of the total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

[#] The numerical assemblage parameters S_a (number of animal taxa) and $\log_{10}(N_a+1)$ (log transformed animal count) are defined in Section 5.2.1.

[*] Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not the other because the overall significance of the Factor SS is higher for the one than for the other.

significant 52 percent of the Factor SS for number of taxa and 46 percent for number of individuals.

The group means from this analysis are shown in Figure 22. As indicated in this figure, Ebey's Landing assemblage parameters were the only ones significantly larger than any others according to the Newman-Keuls procedure for comparing all means. Year-to-year differences were insignificant at the sites for which two years of data were available.

Of course, the failure of a statistical test to detect differences is no guarantee that none exist. For example, if we had only the 1976 summer samples from North Beach and the 1977 summer samples from Dungeness Spit, either a two-sample t-test or a Mann-Whitney test between the two groups of samples would indicate significant differences in number of taxa at about the 1 percent level. We would get only a slightly less significant indication of site difference if we included both the 1976 and 1977 summer data. This is a site difference that most biologists would agree is real. We will confront the issue of power of tests to detect real differences at exposed sand and gravel sites in Section 6.2.3.

Analyses of assemblage parameter variability,
protected soft substrate sites:

Analysis of variance at moderately protected sites: Cluster analyses indicated little similarity in species and counts of animals between the moderately protected NPS sites, Birch Bay (sand) and Guemes Island South (gravel), and any other baseline sites although they sometimes clustered with Beckett Point, North Beach, and Eagle Cove. An analysis of variance which included data from low and mid elevations at these sites showed that the NPS sites were poorer in species and individuals than Beckett Point and more like the moderately exposed sand sites.

We therefore compared Birch Bay and Guemes Island with the moderately exposed SJI sites, Eagle Cove (sand) and Deadman Bay (gravel). A one-way analysis of variance with each group consisting of July 1976 data from a particular site and elevation stratum was performed. The groups proved to be significantly different at the 1 percent level for all three numerical assemblage parameters considered (Figure 23).

The contrasts used to explore these differences and the percent of Factor SS that each explained are given in Table 21. This table reinforces the results of cluster analyses of these sites. Like Deadman Bay, Birch Bay and Guemes Island appear to be unique sites not much like any of the other baseline sites. They exhibited somewhat less vertical stratification than Eagle Cove and Deadman Bay. Guemes Island had a larger number of different taxa but significantly fewer individuals than Deadman Bay. Numbers of individuals at Birch Bay were low compared to Eagle Cove. The sand sites and Guemes Island were much more diverse than Deadman Bay, perhaps because Deadman Bay had very little sand while Guemes Island sediment had 40 to 50 percent sand mixed with its gravel and pebbles.

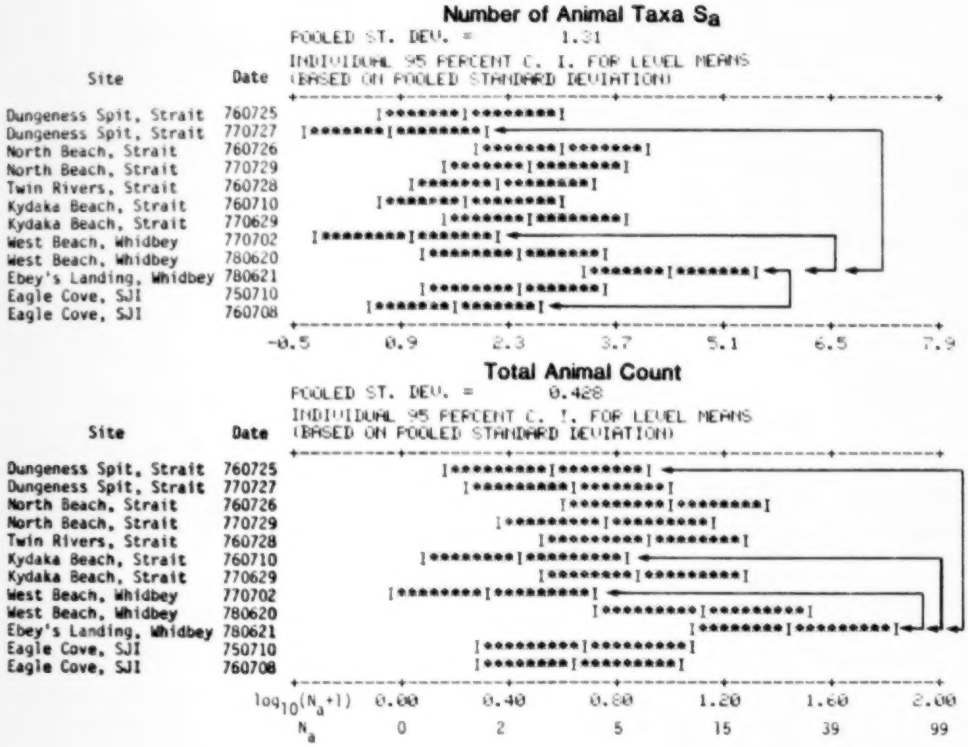


Figure 22. Group means from analysis of variance of numerical assemblage parameters (defined in Section 5.2.1) at upper intertidal exposed sand and gravel sites, summer, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations. The one-way analysis of variance model (A.3.1) of Appendix A with $n_i = 5$ in each group was used. Axis labels for total animal count are shown in untransformed as well as log transformed units. Arrows indicate differences which were significant at the 5 percent level according to the Newman-Keuls procedure for comparing all means, see Section A.3 of Appendix A.

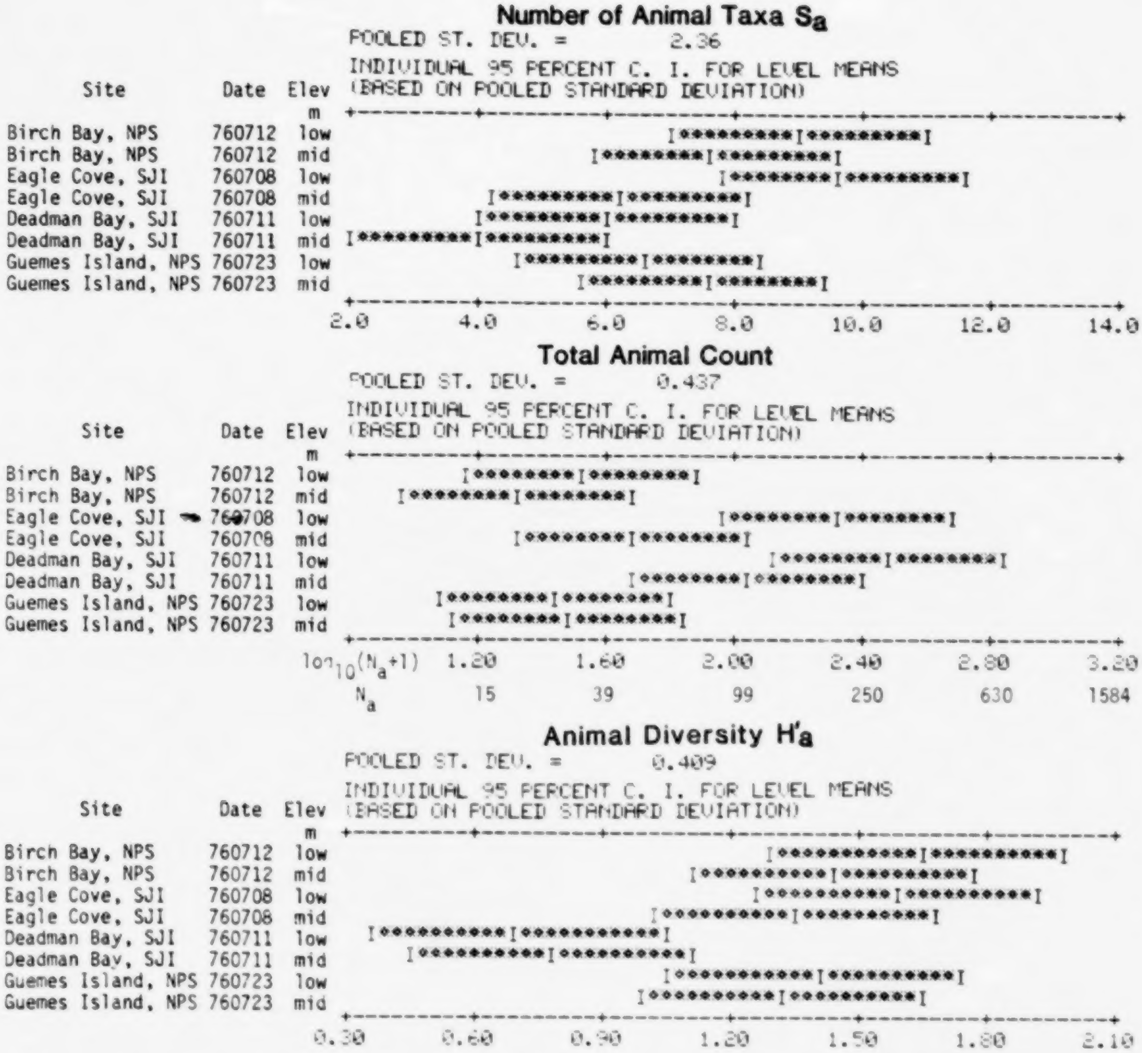


Figure 23. Group means from analysis of variance of numerical assemblage parameters (defined in Section 5.2.1) at moderately protected intertidal sand and gravel sites, July 1976, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations. The one-way analysis of variance model (A.3.1) of Appendix A with $n_i = 6$ in each group was used. The low elevation groups include data from −0.3 m to 0.4 m, the mid elevation groups data from 0.5 m to 1.2 m. At Birch Bay 11 samples had been taken in the low elevation range; the five most extreme elevations were omitted to maintain equal group sizes for the analysis. High elevations were not considered in this analysis because they were not sampled at Birch Bay. Some care should be used in interpreting these results since the maximum F ratio (A.3.10) indicated variance heterogeneity in $\log_{10}(N_a+1)$ and H'_a.

TABLE 21. CONTRIBUTIONS OF SITE AND ELEVATION DIFFERENCES TO VARIABILITY IN JULY 1976 MODERATELY PROTECTED SAND AND GRAVEL ASSEMBLAGE PARAMETERS

	% of Factor SS†		
	S_a#	$\log_{10}(N_a+1)$	H'_a
SITE DIFFERENCES (comparing averages over both elevations):			
Birch Bay vs. Eagle Cove	1%	25	1
Deadman Bay vs. Guemes Island	17	49 *	45 *
Sand vs. gravel (Birch Bay/Eagle Cove average vs. Guemes Island/Deadman Bay average)	40	4	48 *
LOW ELEVATION VS. MID:			
Birch Bay	4	1	2
Eagle Cove	27	15	3
Deadman Bay	9	6	1
Guemes Island	2	0	0
	100%	100%	100%

† The Factor SS represents the fraction of total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

# The numerical assemblage parameters S_a (number of animal taxa), $\log_{10}(N_a+1)$ (log transformed animal count), and H'_a (animal diversity) are defined in Section 5.2.1.

* Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not another because the overall significance of the Factor SS is greater for the one than for the other.

Multiple regressions to partition variability at each site: Contributions of elevation, season, and time trends to variability at each protected soft substrate site were assessed using the multiple regression model (A.2.1) with y_j a value of S_a, $\log_{10}(N_a+1)$, or $\log_{10}(W_a+1)$. Results are in Table 22.

The Birch Bay analysis included all 177 available samples taken between October 1974 and August 1976, mostly at low to mid elevations. The multiple regression model explained only a small percentage of the variability in assemblage parameters at Birch Bay. Sampling variability appears to dominate other factors at this site. It is possible that there are undetected data errors contributing to the results, but it may also be that Birch Bay simply represents a habitat that cannot be modelled well in terms of temporal and spatial factors.

The estimated elevation coefficients were not significantly different from zero, but they defined curves which decrease at high elevations as we would expect. Recall that the analysis of variance results of Table 21 had also indicated that elevation was not an important factor at Birch Bay. Season coefficients indicated lower numbers of animals and animal species but higher weights in spring and summer than in fall and winter. A long-term increase through time in all three parameters was also indicated.

The multiple regression model worked better on the 178 samples taken at Fidalgo Bay between November 1974 and August 1976. As can be seen in Table 22, animal weight results were much like those at Birch Bay. However, the model explained more than 50 percent of the variability in each of the other two parameters.

Elevation was a more significant factor at Fidalgo than at Birch Bay. Elevations of the samples at Fidalgo Bay ranged from 0.1 m to 1.6 m with most in the range 0.4 m to 1.2 m. The elevation coefficients for S_a and $\log_{10}(N_a+1)$ implied decreases in these parameters with increasing elevation up to about 0.9 m but increases at higher elevations. The estimated season and date coefficients, at Fidalgo Bay as at Birch Bay, were much more significant than the elevation coefficients. Both were positive and significant for all three assemblage parameters, indicating larger parameter values in spring and summer than in fall and winter as well as increases over the course of the study. Seasonal differences contributed 35 percent of the variability in S_a and 23 percent in $\log_{10}(N_a+1)$ while the long-term time trend accounted for 19 percent and 35 percent, respectively.

The pitfalls of a multiple regression model can be illustrated by considering the results (Table 23) of fitting the same model to 86 Birch Bay samples and 91 Fidalgo Bay samples taken at elevations between -0.3 m and +1.3 m and dates between August 1975 and August 1976 inclusive. The fitted equations and their implications sometimes differed significantly.

Webber did not identify amphipods to species level in samples taken before August 1975. While we had lumped most gammarids in our analyses for this reason, we had retained a few key genera such as Corophium that appeared to be frequently identified to genus or species. We had also retained all

TABLE 22. RESULTS OF REGRESSIONS TO PARTITION ASSEMBLAGE PARAMETER VARIABILITY, PROTECTED SOFT SUBSTRATE INTERTIDAL SITES

Site	y †	Regression Equation (standard deviations of coefficients in parentheses)	Contributions to R^2 * Elevation (x_1)	Elevation Squared (x_2)	Season (x_3)	Date (x_4)	Total R^2	Residual Standard Deviation
Birch Bay	S_a	$- 87 - 0.80x_1 - 0.22x_2 - 2.24x_3 + 1.28x_4$ (50.5) (0.90) (0.75) (0.77) (0.67)	0.7% +	0.0% +	3.1% +	2.0% =	5.8%	4.65
	$\log_{10}(N_a+1)$	$- 15.4 - 0.00x_1 - 0.04x_2 - 0.24x_3 + 0.22x_4$ (5.15) (0.09) (0.08) (0.08) (0.07)	0.0	0.1	1.9	5.7	7.7	0.474
	$\log_{10}(W_a+1)$	$- 7.16 + 0.01x_1 - 0.05x_2 + 0.09x_3 + 0.10x_4$ (2.94) (0.05) (0.04) (0.04) (0.04)	0.7	0.5	5.7	3.4	10.3	0.271
Fidalgo Bay	S_a	$- 382 - 8.72x_1 + 5.05x_2 + 5.09x_3 + 5.24x_4$ (47.1) (4.70) (2.84) (0.69) (0.63)	0.2	0.0	35.1	18.6	53.9	4.20
	$\log_{10}(N_a+1)$	$- 40.9 - 1.09x_1 + 0.82x_2 + 0.23x_3 + 0.57x_4$ (3.19) (0.32) (0.19) (0.05) (0.04)	7.3	0.9	23.4	34.6	66.2	0.284
	$\log_{10}(W_a+1)$	$- 14.9 + 0.38x_1 - 0.21x_2 + 0.18x_3 + 0.21x_4$ (4.38) (0.44) (0.26) (0.06) (0.06)	0.4	1.0	9.7	6.0	17.1	0.390
Westcott Bay	S_a	$171 - 4.79x_1 - 1.16x_2 - 0.14x_3 - 1.87x_4$ (56.2) (1.27) (0.73) (0.86) (0.74)	64.8	1.1	0.3	2.5	68.7	3.75
	$\log_{10}(N_a+1)$	$3.69 - 0.18x_1 - 0.07x_2 - 0.14x_3 - 0.00x_4$ (3.5) (0.08) (0.05) (0.05) (0.05)	48.8	2.0	4.1	0.0	54.9	0.234
Webb Camp	S_a	$- 5.04 - 7.50x_1 - 2.78x_2 - 3.09x_3 + 0.54x_4$ (62.2) (1.55) (0.81) (1.02) (0.83)	78.5	2.6	1.7	0.1	82.9	4.74
	$\log_{10}(N_a+1)$	$- 6.65 - 0.44x_1 - 0.12x_2 - 0.19x_3 + 0.13x_4$ (4.76) (0.12) (0.06) (0.08) (0.06)	64.2	1.7	1.6	1.6	69.1	0.363
Beckett Point	S_a	$- 401 - 39.5x_1 + 7.75x_2 - 3.21x_3 + 5.95x_4$ (216) (6.31) (3.26) (3.11) (2.79)	70.9	2.3	2.3	1.6	77.1	10.9
	$\log_{10}(N_a+1)$	$- 11.8 - 0.79x_1 + 0.00x_2 - 0.21x_3 + 0.20x_4$ (7.10) (0.21) (0.11) (0.10) (0.09)	68.1	0.0	5.4	1.8	75.3	0.357
Jamestown	S_a	$- 380 - 43.8x_1 + 12.2x_2 - 2.60x_3 + 5.51x_4$ (123) (5.26) (2.69) (1.78) (1.59)	76.8	5.4	2.9	2.3	87.4	6.17
	$\log_{10}(N_a+1)$	$0.643 - 1.11x_1 + 0.45x_2 - 0.10x_3 + 0.04x_4$ (10.9) (0.47) (0.24) (0.16) (0.14)	10.0	5.5	1.1	0.1	16.7	0.548

* R^2, the percentage of total variability explained by the multiple regression model (A.2.1) of Appendix A, is defined by (A.2.3).

† The numerical assemblage parameters, for example number of animal taxa S_a, used as dependent variables y_j in (A.2.1) are defined in Section 5.2.1. The subscripts j of (A.2.1) have been omitted in this table for conciseness.

TABLE 23. RESULTS OF REGRESSIONS OVER RESTRICTED RANGES OF ELEVATIONS AND DATES, BIRCH BAY AND FIDALGO BAY

			Contributions to R^2 *					
Site	y †	Regression Equation (standard deviations of coefficients in parentheses)	Elevation # (x_1)	Elevation Squared (x_2)	Season (x_3)	Date § (x_4)	Total R^2	Residual Standard Deviation
Birch Bay	S_a	$-284 - 1.86x_1 + 0.05x_2 - 3.36x_3 + 3.88x_4$ (118) (1.93) (2.50) (1.00) (1.55)	3.5% +	0.3% +	6.6%	+ 6.5% =	16.9%	4.08
	$\log_{10}(N_a+1)$	$-42.4 - 0.19x_1 + 0.16x_2 - 0.40x_3 + 0.58x_4$ (10.5) (0.17) (0.22) (0.09) (0.14)	0.4	1.8	8.0	15.9	26.1	0.364
	$\log_{10}(W_a+1)$	$-8.51 + 0.16x_1 - 0.27x_2 + 0.11x_3 + 0.12x_4$ (9.06) (0.15) (0.19) (0.08) (0.12)	0.2	3.6	4.9	1.1	9.8	0.314
Fidalgo Bay	S_a	$448 + 17.7x_1 - 11.1x_2 + 7.52x_3 - 5.79x_4$ (106) (7.21) (4.38) (0.81) (1.41)	3.9	0.2	39.0	9.3	52.4	3.44
	$\log_{10}(N_a+1)$	$-0.35 - 0.31x_1 + 0.41x_2 + 0.35x_3 + 0.03x_4$ (7.52) (0.51) (0.31) (0.06) (0.10)	7.9	4.2	30.8	0.1	43.0	0.244
	$\log_{10}(W_a+1)$	$29.1 + 0.57x_1 - 0.31x_2 + 0.21x_3 - 0.37x_4$ (12.1) (0.83) (0.50) (0.09) (0.16)	0.1	0.6	2.3	5.7	8.7	0.393

* R^2, the percentage of total variability explained by the multiple regression model (A.2.1) of Appendix A, is defined by (A.2.3).

† The numerical assemblage parameters, for example number of animal taxa S_a, used as dependent variables y_j in (A.2.1) are defined in Section 5.2.1. The subscripts j of (A.2.1) have been omitted in this table for conciseness.

Only elevations between -0.3 m and +1.3 m were included in this analysis.

§ Only dates between August 1975 and August 1976 were included in this analysis.

caprellid amphipod species in our dictionary. We hypothesized that the apparent significant increase in S_a at Fidalgo Bay was due to this discrepancy in identification level (and perhaps others). Indeed, in the analysis of Table 23 that does not include the data before August 1975, the date coefficient indicates a decrease in S_a during the second year of the study. Clearly the taxonomic problems discussed in Section 4.2.4 make it difficult to use the present data base to draw meaningful conclusions about long-term temporal variability in species richness.

We omitted the lowest elevations sampled at Birch Bay and the highest at both sites for the analysis of Table 23 because the Minitab output corresponding to Table 22 had indicated that these extreme elevations had large influence on the fitted equations. As expected, the new equations indicated a significant decrease rather than increase in S_a at high elevations. The magnitude and significance of the elevation coefficients for $\log_{10}(N_a+1)$ at Fidalgo Bay were also reduced in the new analysis.

The dominance of seasonal effects as a source of variability at Fidalgo Bay was clearer in Table 23 than in the previous table. The spring/summer increase accounted for 39 percent of the variability in S_a and over 30 percent in $\log_{10}(N_a+1)$ in the data taken between August 1975 and August 1976. In most other respects, results in the two tables were similar.

The main conclusion to be drawn from Tables 22 and 23 is that regression results should be used only as indicators of the relative importance of various factors. Thus, at Birch Bay neither elevation nor temporal factors appear to be significant relative to sampling variability, whereas at Fidalgo Bay the spring/summer increase in numbers of animal species and individuals accounts for about a third of the variability in these parameters. Animal weights appear to be relatively insensitive to elevation and sampling date at both sites.

At the other four sites included in Table 22, sample elevation was by far the most significant factor, generally accounting for 50 to 80 percent of the variability in S_a and $\log_{10}(N_a+1)$. Since these sites were all sampled by Nyblade, who recorded animal weights with less regularity than Webber, we did not examine W_a. Except for $\log_{10}(N_a+1)$ at Jamestown, for which elevation was less significant, the fitted curves indicated decreases in S_a and N_a with increasing elevation inside the range of elevations sampled.

It seems likely that the negative season coefficients, mostly insignificant, represent data anomalies rather than a real spring/summer decline in S_a or N_a. In fact, when a similar model was fit to a subset of data consisting of only low to mid elevation summer and winter samples, the season coefficients indicated either insignificant seasonal changes or summer increases in both S_a and N_a at all four sites. Decreases in S_a and N_a with increasing elevation dominated R^2 even over the more limited elevation range.

Long-term time trends are insignificant at the Nyblade sites except possibly for the indicated decrease in S_a at Westcott Bay and the increase at Jamestown. The positive value at Jamestown may be at least partly due to improved identification of species as the MESA study progressed. The negative estimate at Westcott Bay may be influenced by the fact that Nyblade attempted to identify amphipods to species in the first but not the second year of the WDOE study.

Analysis of relative contributions of season and site differences to variability, protected soft substrate sites: Seasonal and site differences were compared in an analysis of variance of fall 1975 and winter, spring, and summer 1976 samples from Birch Bay, Webb Camp, Westcott Bay, and Fidalgo Bay and spring, summer, and fall 1976 and winter 1977 samples from Beckett Point and Jamestown.

Three samples at the lowest available elevations (-0.3 m to 0.6 m) were used at each selected date and site. It was realized that elevation effects might increase replicate variability in this analysis, but samples with identical elevations were simply not available for cross-site comparisons. For example, 0.5 m was the lowest regularly sampled elevation at Fidalgo Bay while -0.3 m was the low elevation at Westcott Bay and 0.6 m the mid elevation, so it did not seem unreasonable to include both low and mid elevation Westcott Bay samples for purposes of comparison with Fidalgo Bay. The maximum F-ratio test indicated no variance heterogeneity in the assemblage parameters considered, providing a partial confirmation of our approach.

Groups included in the analysis and their means are shown in Figure 24. Contrasts used to quantify the obvious group differences are presented in Table 24. Clearly, site differences far outweighed seasonal differences at a site, accounting for 70 to 90 percent of the between-group variability. Northern Sound sites, particularly those sampled by Webber, were clearly different from Strait sites.

Not surprisingly, Webb Camp and Westcott Bay were the most similar of the site pairs considered. Both sites are in fact in Westcott Bay. The sampling dates included in this analysis were almost the same at the two sites. Furthermore, as we will see in a moment, sediment composition at the two sites was relatively similar, especially at the low elevation.

The NPS sites Birch Bay and Fidalgo Bay were somewhat similar to each other though on the average Birch Bay had lower values of all three assemblage parameters. Both were significantly poorer in species and individuals than the other sites.

Jamestown and Beckett Point, though both are protected sites in the eastern Strait of Juan de Fuca, were very dissimilar to each other and to the other sites. Beckett Point exhibits an unusual fall peak in numbers of taxa and individuals, and the spring samples were anomalously low in these parameters, accounting for the significant seasonal as well as site contrasts involving Beckett Point.

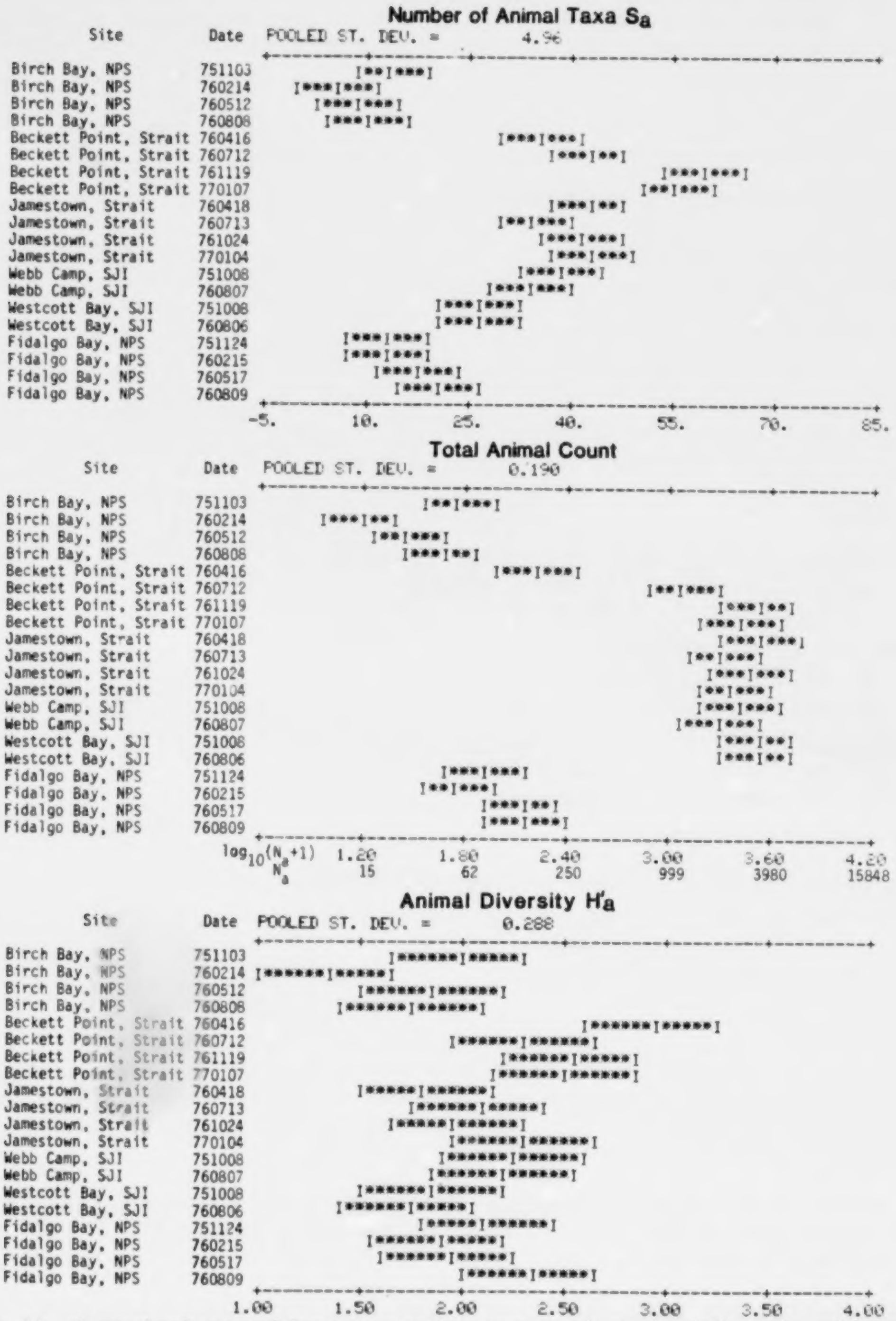


Figure 24. Numerical assemblage parameter means at protected soft substrate sites, low to mid intertidal, all seasons, with individual 95 percent confidence intervals (A.1.7).

TABLE 24. CONTRIBUTIONS OF SITE AND SEASON DIFFERENCES TO VARIABILITY IN LOW TO MID INTERTIDAL PROTECTED SOFT SUBSTRATE ASSEMBLAGE PARAMETERS

	% of Factor SS†		
	S_a#	$\log_{10}(N_a+1)$	H'_a
SITE (averaged over all seasons):			
Birch Bay vs. Fidalgo Bay	2%	3%*	10%
Webb Camp vs. Westcott Bay	2	0	8
Beckett Point vs. Jamestown	2*	2*	23*
Birch/Fidalgo vs. Webb/Westcott	19*	55*	1
North Sound vs. Strait (average of Birch/Fidalgo/Webb/Westcott vs. average of Beckett/Jamestown)	64*	30*	28*
SEASONS:			
Birch Bay fall (751103) vs. winter (760214)	1	1	9
spring (760512) vs. summer (760808)	0	0	0
spring/summer vs. fall/winter	0	0	1
Beckett Point fall (761119) vs. winter (770107)	0	0	0
spring (760416) vs. summer (760712)	1	3*	9
spring/summer vs. fall/winter	7*	5*	0
Jamestown fall (761024) vs. winter (770104)	0	0	3
spring (760418) vs. summer (760713)	1	0	1
spring/summer vs. fall/winter	0	0	2
Webb Camp fall (751007) vs. summer (760807)	0	0	0
Westcott Bay fall (751008) vs. summer (760806)	0	0	0
Fidalgo Bay fall (751124) vs. winter (760215)	0	0	1
spring (760517) vs. summer (760809)	0	0	3
spring/summer vs. fall/winter	1	1	1
	100%	100%	100%

---

† The Factor SS represents the fraction of total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

# The numerical assemblage parameters S_a (number of animal taxa), $\log_{10}(N_a+1)$ (log transformed animal count), and H'_a (animal diversity) are defined in Section 5.2.1.

* Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not another because the overall significance of the Factor SS is greater for the one than for the other.

The analyses summarized by Table 24 and Figure 24, like those discussed earlier, point to deficiencies in a priori habitat definitions. The relative poverty of Birch Bay is consistent with its definition as a moderately protected sand habitat as opposed to the other sites which were characterized as protected mud or mixed. However, the a priori definitions would lead us to expect the protected mud habitats Jamestown, Westcott Bay, and Fidalgo Bay to be similar to one another and less similar to the mixed sites, Beckett Point and Webb Camp.

The available sediment size data supplemented by the investigators' descriptions tell a slightly different story. It is impossible to tabulate percentage of sediment in each size class precisely because different classification schemes were used in the different studies and replicate samples, when available, often indicated quite different percentages. In addition, only 1974-1975 sediment data are available at the SJI sites to go with the 1976 biological data. Combining all the available information, we obtain Table 25. The sites in the table are ordered roughly by percentage of mud (fine sand to silt.) The question marks on the Birch Bay entries mean that the sediment data available did not discriminate between fine and medium sand. The classification as medium was based on Nyblade's (1979b) description of the site.

We see that the low elevation of Webb Camp, in particular, is more like muddy Westcott Bay than mixed Beckett Point. The low elevation at Jamestown is closer to Birch Bay in sediment than to the "mud" sites, and there is a definite gradient in the fineness of the "mud" with Jamestown least fine, Fidalgo Bay finest, and Webb and Westcott in between.

TABLE 25. PERCENT OF SEDIMENT BY GRAIN SIZE, PROTECTED SOFT SUBSTRATE SITES

Site	Elevation, meters	Finest sand to silt	Fine sand	Medium sand	Coarse sand	Gravel or larger
Birch Bay	-0.3	5%	0%(?)	95%(?)	0%	0%
Beckett Point	0.0	0 to 5	15 to 25	35 to 50	10 to 15	10 to 35
Jamestown	0.0	0	5	90	0 to 5	0 to 5
	0.4	5 to 10	85	5	0 to 5	0 to 5
Webb Camp	-0.3	35 to 40	40	15	5 to 10	0
	0.6	15	25 to 30	5 to 10	25 to 30	25 to 30
Westcott Bay	-0.3	60	25	5 to 10	5	0 to 5
	0.6	55 to 65	15	10	5 to 15	0
Fidalgo Bay	0.5	95 to 100	0 to 5	0 to 5	0	0

In short, the "habitat" at a site may vary considerably with elevation and date. "Habitat" definitions are clarified by sediment size data, preferably taken concurrently with the biological data. Such data may help to explain similarities and differences which don't make sense in terms of a priori definitions.

Relative contributions of elevation and site differences, protected soft substrate sites, summer: The contributions of these factors to variability were assessed by considering all available samples at low to mid elevations taken in summer, 1976, at Jamestown, Webb Camp, Westcott Bay, and Fidalgo Bay. Higher elevations were omitted because they were anomalous at Jamestown and unavailable at Fidalgo Bay. Birch Bay and Beckett Point were eliminated because the analyses already discussed indicated that they differed greatly from the other four sites. The groups in the analysis and their means are plotted in Figure 25.

Figure 25 indicates that the most dramatic elevation differences occurred at Jamestown, with the 0.6 m elevation having fewer species than the lower ones. Elevation effects were indistinct at Fidalgo Bay, but only a narrow range of elevations was sampled there. Differences between the June and August samples at Webb Camp and Westcott Bay were small, indicating that, at least in summer, within-season variability is not highly significant.

For further elucidation of the relative importance of site and elevation, we considered a set of six orthogonal contrasts for elevation effects and the remaining portion of the Factor SS which can be assumed to be due largely to site effects (Table 26). A full set of orthogonal contrasts was not constructed for this analysis because unequal group sizes made the task too difficult. Site differences in animal count surpassed elevation differences in importance, largely due to the low values at Fidalgo Bay. Elevation effects dominated in the other parameters, largely due to the large difference of the 0.6 m elevation from the others at Jamestown.

Year-to-year variability, protected soft substrate sites: A final analysis of low-elevation data from Beckett Point and Westcott Bay was performed to assess year-to-year variability (Figure 26 and Table 27). Two years of quarterly data were available at Beckett Point and two years for all seasons but fall at Westcott Bay. As in the analysis of elevation versus site differences, we did not attempt to construct a complete set of orthogonal contrasts due to unequal group sizes.

The only highly significant between-year difference occurred in the spring samples at Beckett Point, one of the many examples in the data set of greater variability in spring than in other seasons. Clearly, site differences (which in this case could be interpreted as differences between mixed fine and mud habitats) far outweigh year-to-year differences in significance. In terms of animal diversity, neither site nor year differences were highly significant.

Number of Animal Taxa S_a

```
      Site         Date  Elev  # of   POOLED ST. DEV. =        3.67
                           m  Samples +---------+---------+---------+---------+---------+---------+
Jamestown, Strait 760708  0.3    2                                        I******I******I
Jamestown, Strait 760708  0.4    3                        I****I*****I
Jamestown, Strait 760708  0.6    2           I******I*****I
Jamestown, Strait 760713  0.0    3                                          I****I*****I
Webb Camp, SJI    760612 -0.3    2                                        I******I******I
Webb Camp, SJI    760612  0.6    3                                 I*****I****I
Webb Camp, SJI    760807 -0.3    2                                       I*****I******I
Webb Camp, SJI    760807  0.6    3                                  I****I****I
Westcott Bay, SJI 760611 -0.3    2                                I*****I******I
Westcott Bay, SJI 760611  0.6    2                          I******I*****I
Westcott Bay, SJI 760806 -0.3    2                                I******I******I
Westcott Bay, SJI 760806  0.6    2                           I******I******I
Fidalgo Bay, NPS  760613  0.5    5                         I***I***I
Fidalgo Bay, NPS  760613  0.6    4                          I***I****I
Fidalgo Bay, NPS  760613  0.7    2                    I******I*****I
Fidalgo Bay, NPS  760809  0.5    3                        I*****I****I
                                      +---------+---------+---------+---------+---------+---------+
                                     0.0       8.0      16.0      24.0      32.0      40.0      48.0
```

Total Animal Count

```
      Site         Date  Elev  # of   POOLED ST. DEV. =       0.226
                           m  Samples +---------+---------+---------+---------+---------+---------+
Jamestown, Strait 760708  0.3    2                             I*****I******I
Jamestown, Strait 760708  0.4    3                  I****I****I
Jamestown, Strait 760708  0.6    2                           I******I*****I
Jamestown, Strait 760713  0.0    3                                   I****I*****I
Webb Camp, SJI    760612 -0.3    2                                I******I*****I
Webb Camp, SJI    760612  0.6    3                               I*****I****I
Webb Camp, SJI    760807 -0.3    2                              I******I******I
Webb Camp, SJI    760807  0.6    3                                  I*****I****I
Westcott Bay, SJI 760611 -0.3    2                                      I*****I******I
Westcott Bay, SJI 760611  0.6    2                          I******I*****I
Westcott Bay, SJI 760806 -0.3    2                                         I******I*****I
Westcott Bay, SJI 760806  0.6    2                                 I******I*****I
Fidalgo Bay, NPS  760613  0.5    5                I***I***I
Fidalgo Bay, NPS  760613  0.6    4               I****I***I
Fidalgo Bay, NPS  760613  0.7    2       I******I*****I
Fidalgo Bay, NPS  760809  0.5    3            I****I*****I
                                      +---------+---------+---------+---------+---------+---------+
                                  log10(Na+1) 2.00      2.50      3.00      3.50      4.00      4.50
                                        Na     99        315       999       3161      9999     31622
```

Animal Diversity H'_a

```
      Site         Date  Elev  # of   POOLED ST. DEV. =       0.186
                           m  Samples +---------+---------+---------+---------+---------+---------+
Jamestown, Strait 760708  0.3    2                                      I****I***I
Jamestown, Strait 760708  0.4    3                                  I***I***I
Jamestown, Strait 760708  0.6    2    I****I***I
Jamestown, Strait 760713  0.0    3                                   I***I**I
Webb Camp, SJI    760612 -0.3    2                                        I****I***I
Webb Camp, SJI    760612  0.6    3                                 I***I***I
Webb Camp, SJI    760807 -0.3    2                                         I***I****I
Webb Camp, SJI    760807  0.6    3                           I**I***I
Westcott Bay, SJI 760611 -0.3    2                              I***I****I
Westcott Bay, SJI 760611  0.6    2                            I****I***I
Westcott Bay, SJI 760806 -0.3    2                           I****I***I
Westcott Bay, SJI 760806  0.6    2                               I****I***I
Fidalgo Bay, NPS  760613  0.5    5                                     I**I**I
Fidalgo Bay, NPS  760613  0.6    4                                       I**I**I
Fidalgo Bay, NPS  760613  0.7    2                                       I****I***I
Fidalgo Bay, NPS  760809  0.5    3                                       I***I**I
                                      +---------+---------+---------+---------+---------+---------+
                                    0.00      0.60      1.20      1.80      2.40      3.00      3.60
```

Figure 25. Group means from analysis of variance of numerical assemblage parameters at protected soft substrate sites, low and mid intertidal, summer, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations.

TABLE 26. CONTRIBUTIONS OF SITE AND ELEVATION DIFFERENCES TO VARIABILITY IN PROTECTED SOFT SUBSTRATE SUMMER ASSEMBLAGE PARAMETERS, LOW AND MID INTERTIDAL

	% of Factor SS[†]		
	S_a[#]	$\log_{10}(N_a+1)$	H'_a
SITE: (Percentage of Factor SS, nine degrees of freedom, representing site differences primarily)	42%*	86%*	41%*
ELEVATION: (Contrasts, each with one degree of freedom)			
Jamestown 0.0 vs. 0.4 meters	18 *	10 *	0
0.3 vs. 0.6	33 *	0	45 *
Webb Camp 760612 -0.3 vs. 0.6	3	0	3
760807 -0.3 vs. 0.6	2	0	10 *
Westcott 760611 -0.3 vs. 0.6	1	3	0
760806 -0.3 vs. 0.6	1	1	1 *
	100%	100%	100%

[†] The Factor SS represents the fraction of total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

[#] The numerical assemblage parameters S_a (number of animal taxa), $\log_{10}(N_a+1)$ (log transformed animal count), and H'_a (animal diversity) are defined in Section 5.2.1.

* Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not another because the overall significance of the Factor SS is greater for the one than for the other.

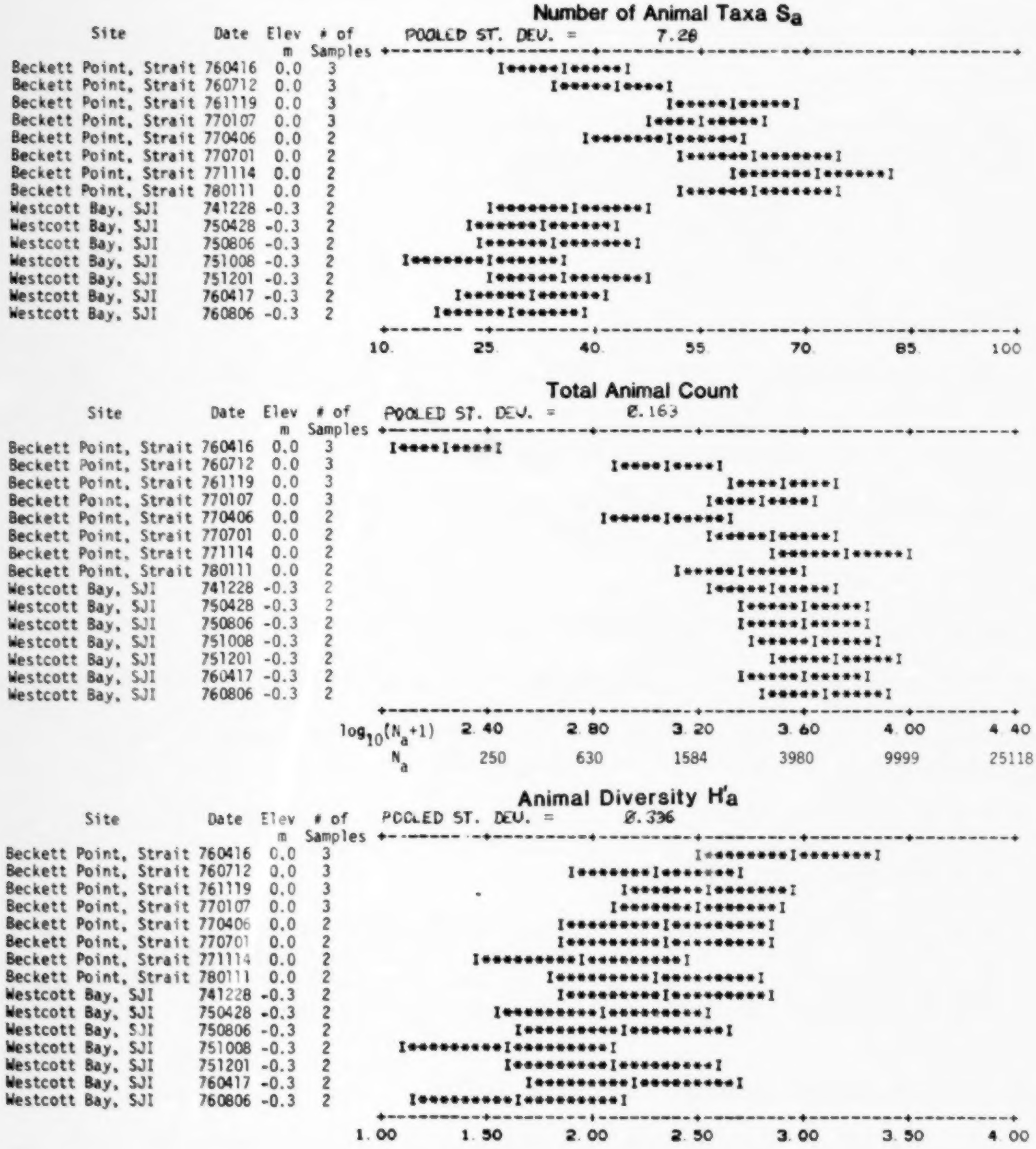


Figure 26. Group means from analysis of variance of numerical assemblage parameters at protected soft substrate sites, low intertidal, all years and seasons, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations.

TABLE 27. CONTRIBUTIONS OF YEAR-TO-YEAR CHANGES TO VARIABILITY IN LOW ELEVATION PROTECTED SOFT SUBSTRATE ASSEMBLAGE PARAMETERS

		% of Factor SS †		
		S_a #	$\log_{10}(N_a+1)$	H'_a
SITE AND SEASON (Percentage of Factor SS, seven degrees of freedom, representing site and season differences):		83%*	79%*	71%
YEAR (Contrasts by site and season):				
Beckett Point	April 1976 vs. 1977	4	16*	10
	July	8	3	0
	November	3	1	11
	January 1977 vs. 1978	1	0	1
Westcott Bay	December 1974 vs. 1975	0	1	1
	April 1975 vs. 1976	0	0	0
	August	1	0	6
		100%	100%	100%

† The Factor SS represents the fraction of total variability in an assemblage parameter explained by the one-way analysis of variance model. It is defined in Table A-2 of Appendix A, and its partitioning by means of contrasts is explained in the discussion following that table.

The numerical assemblage parameters S_a (number of animal taxa), $\log_{10}(N_a+1)$ (log transformed animal count), and H'_a (animal diversity) are defined in Section 5.2.1.

* Significant at the 0.001 level. Our choice of this level for testing is discussed in Section A.4 of Appendix A. Note that the same % of Factor SS may be significant for one parameter but not another because the overall significance of the Factor SS is greater for the one than for the other.

6.2.2 Population analyses

Individual species were not examined for the exposed soft substrate sites since even assemblage parameters were zero in too many samples to permit unrestricted use of regression analysis or analysis of variance. The strong clustering by site exhibited in the soft substrate dendrograms implies that even at protected sites with similar sediment we can expect to find few ubiquitous species.

However, a short list of animals found quite regularly at the most protected sites was compiled and counts of these animals were examined after log transformation. We considered the polychaetes *Eteone longa*, *Glycinde picta*, *Pygospio elegans*, *Pseudopolydora kempi*, *Armandia brevis*, and *Capitella capitata*; the bivalves *Macoma nasuta* and *Transennella tantilla*; and the gammarid amphipod genus *Corophium*. These animals were selected in part because they are relatively easy to identify and were in fact identified at some sites and times by both Nyblade and Webber. Thus it is reasonable to assume that site differences in animal numbers uncovered by analysis of variance are not a result of investigator bias.

An inspection of our tabulation of sites, dates, and elevations in which these animals occurred indicated that we should consider low to mid elevations (-0.3 m to 0.6 m) at the six sites (Birch Bay, Beckett Point, Jamestown, Webb Camp, Westcott Bay, and Fidalgo Bay) included in the assemblage parameter analysis of Figure 24. All available summer 1976 samples in this range of elevations were included in a one-way analysis of variance. Groups in the analysis were defined by site and elevation, with each group containing data from only one of the sites and only the upper or lower half of the elevation range.

Group means with individual 95 percent confidence intervals are shown in Figure 27. Each of the animals except *Glycinde picta* was absent from at least one group. The applicability of the analysis of variance model is therefore questionable, and the plotted confidence intervals may be inaccurate. Nevertheless, Figure 27 points to some clear conclusions.

First, Birch Bay has fewer animals than the other sites, accounting for most of the zero groups. *Eteone longa*, *Armandia brevis*, *Capitella capitata*, *Transennella tantilla*, and *Corophium* were not collected at Birch Bay in these summer 1976 samples although they were found there at other times. The remaining four species considered in this analysis occurred in smaller numbers at Birch Bay than at the other sites. The relative poverty of these populations at Birch Bay is consistent with the assemblage parameter results of Figure 24 and the characterization of Birch Bay as a moderately protected sand rather than a protected mud or mixed habitat.

Habitat definitions supplemented by the sediment data of Table 22 contribute to an understanding of other population characteristics indicated by Figure 27. For example, *Pseudopolydora kempi* occurs in significant numbers only at the two finest mud sites, Westcott Bay and Fidalgo Bay.

Some geographic patterns appear evident. For example, *Transennella tantilla* is most plentiful at the SJI sites and entirely absent at the NPS sites. *Macoma nasuta* is also most dense at the SJI sites and is nearly absent at Beckett Point and Jamestown in the Strait as well as at Birch Bay.

It is difficult, however, to separate effects of substrate, exposure, geography, and other factors. For example, the Webb Camp and Westcott Bay sites, both in Westcott Bay, are similar in terms of exposure and, especially at the lower elevations, substrate. In addition, unlike the other sites,

Capitella capitata

```
        Site            Elevation # of POOLED ST. DEV. =      0.342
                          m  Samples +---------+---------+---------+---------+---------+---------+
Birch Bay, NPS       -0.3 to 0.1 10         I**I**I
Beckett Point, Strait    0.0      3        I****I*****I
Jamestown, Strait        0.0      3                                          I*****I****I
Webb Camp, SJI          -0.3      4                           I****I****I
Westcott Bay, SJI       -0.3      4                                           I****I****I
Birch Bay, NPS        0.2 to 0.6  6        I***I***I
Beckett Point, Strait 0.3 to 0.6  4           I****I****I
Jamestown, Strait     0.3 to 0.6  7                          I**I***I
Webb Camp, SJI           0.6      6                     I***I***I
Westcott Bay, SJI        0.6      4                        I****I***I
Fidalgo Bay, NPS      0.5 to 0.6 12                       I**I*I
                                     +---------+---------+---------+---------+---------+---------+
                              log10(count+1) 0.00      0.70      1.40      2.10      2.80      3.50
                                count          0         4        24       125       630      3161
```

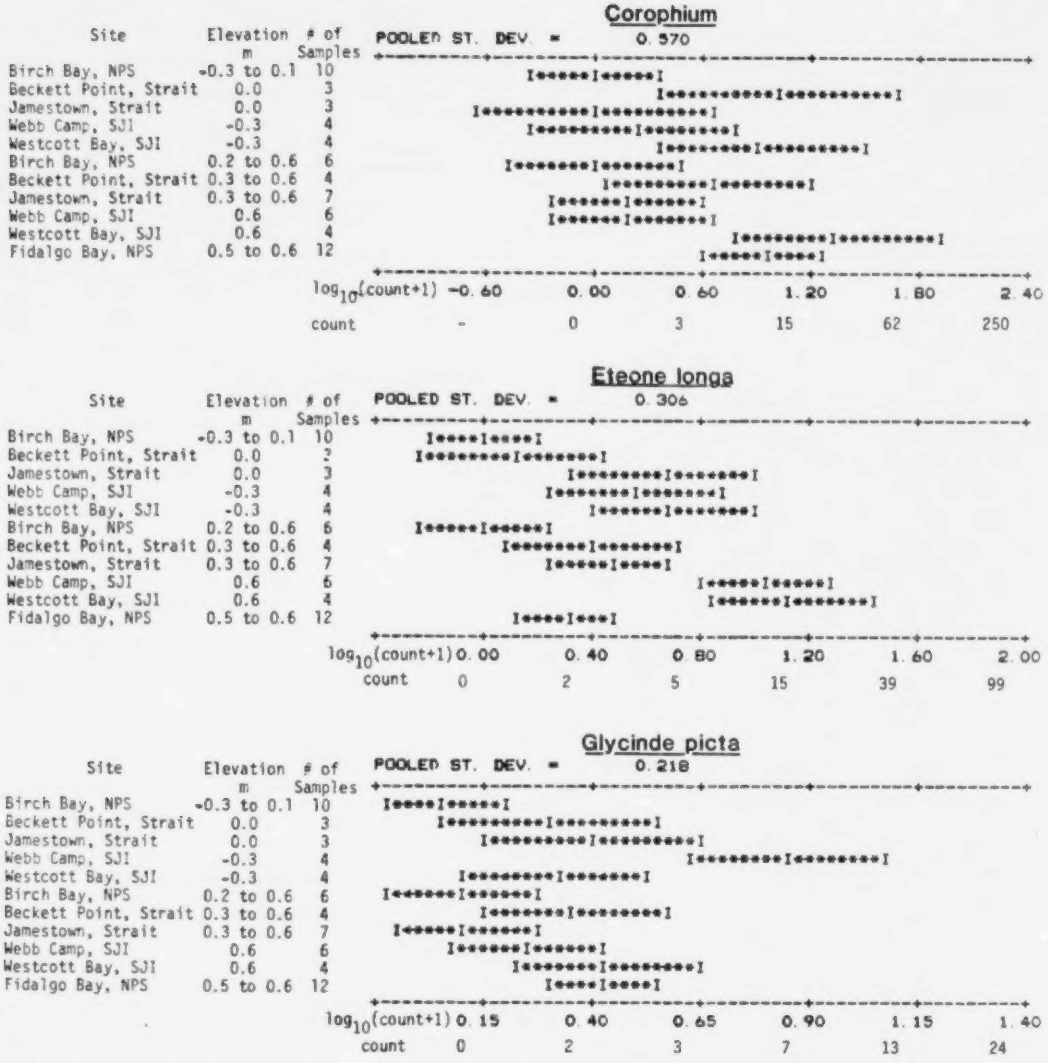
Macoma nasuta

```
        Site            Elevation # of POOLED ST. DEV. =      0.186
                          m  Samples +---------+---------+---------+---------+---------+---------+
Birch Bay, NPS       -0.3 to 0.1 10          I***I***I
Beckett Point, Strait    0.0      3        I******I*******I
Jamestown, Strait        0.0      3     I******I******I
Webb Camp, SJI          -0.3      4                                          I*****I*****I
Westcott Bay, SJI       -0.3      4                                           I*****I******I
Birch Bay, NPS        0.2 to 0.6  6       I****I****I
Beckett Point, Strait 0.3 to 0.6  4        I******I*****I
Jamestown, Strait     0.3 to 0.6  7           I****I***I
Webb Camp, SJI           0.6      6                         I****I****I
Westcott Bay, SJI        0.6      4                                      I*****I*****I
Fidalgo Bay, NPS      0.5 to 0.6 12                 I***I***I
                                     +---------+---------+---------+---------+---------+---------+
                              log10(count+1) 0.00      0.30      0.60      0.90      1.20      1.50
                                count          0         1         3         7        15        31
```

Transennella tantilla

```
        Site            Elevation # of POOLED ST. DEV. =      0.467
                          m  Samples +---------+---------+---------+---------+---------+---------+
Birch Bay, NPS       -0.3 to 0.1 10       I****I****I
Beckett Point, Strait    0.0      3                                I********I********I
Jamestown, Strait        0.0      3                I********I********I
Webb Camp, SJI          -0.3      4                                 I*******I*******I
Westcott Bay, SJI       -0.3      4                                      I*******I******I
Birch Bay, NPS        0.2 to 0.6  6      I*****I*****I
Beckett Point, Strait 0.3 to 0.6  4                           I*******I*******I
Jamestown, Strait     0.3 to 0.6  7                   I*****I*****I
Webb Camp, SJI           0.6      6                                      I*****I*****I
Westcott Bay, SJI        0.6      4                                    I*******I******I
Fidalgo Bay, NPS      0.5 to 0.6 12       I****I****I
                                     +---------+---------+---------+---------+---------+---------+
                              log10(count+1) 0.00      0.60      1.20      1.80      2.40      3.00
                                count          0         3        15        62       250       999
```

Figure 27. Means of log transformed counts for selected animals from protected soft substrate intertidal sites, low to mid elevations, summer 1976, with individual 95 percent confidence intervals (A.1.7) based on pooled standard deviations from analysis of variance. The model (A.3.1) of Appendix A with varying group sizes was used, resulting in varying confidence interval lengths. Because they are based on pooled standard deviations computed from data at all sites, confidence intervals for absent or scarce species at a given site extend above and below zero. Axis labels are in log units with the corresponding counts given below.

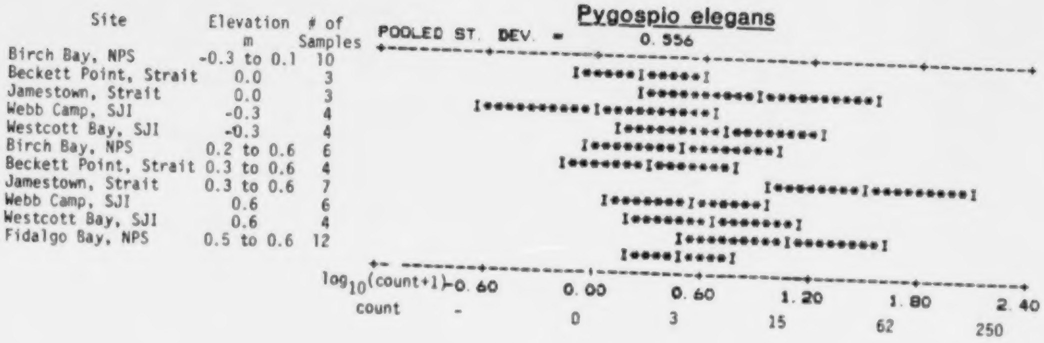


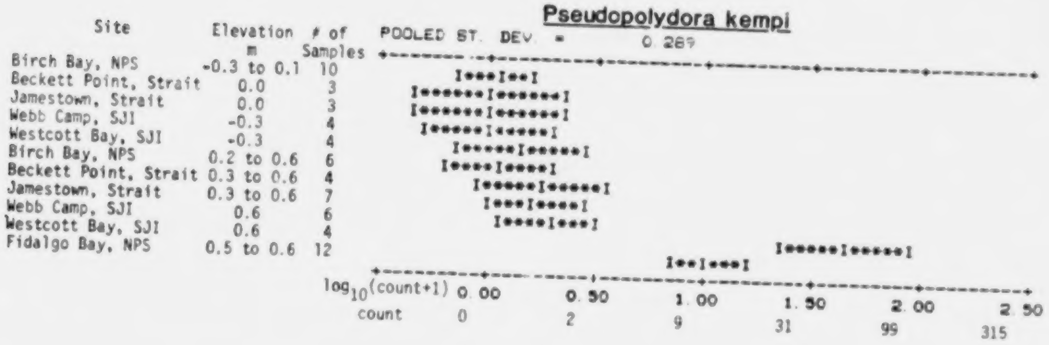
```
                                                         Corophium
          Site            Elevation  # of   POOLED ST. DEV. =      0.570
                            m  Samples +---------+---------+---------+---------+---------+---------+
Birch Bay, NPS         -0.3 to 0.1 10                I*****I*****I
Beckett Point, Strait      0.0      3                            I**********I**********I
Jamestown, Strait          0.0      3           I**********I**********I
Webb Camp, SJI            -0.3      4                I*********I********I
Westcott Bay, SJI         -0.3      4                            I********I*********I
Birch Bay, NPS          0.2 to 0.6  6              I*******I*******I
Beckett Point, Strait   0.3 to 0.6  4                       I*********I********I
Jamestown, Strait       0.3 to 0.6  7                  I******I******I
Webb Camp, SJI             0.6      6                  I******I*******I
Westcott Bay, SJI          0.6      4                                  I********I*********I
Fidalgo Bay, NPS        0.5 to 0.6 12                               I*****I****I
                                       +---------+---------+---------+---------+---------+---------+
                           log10(count+1)     -0.60     0.00      0.60      1.20      1.80      2.40
                           count                -        0         3        15        62       250
```

```
                                                         Eteone longa
          Site            Elevation  # of   POOLED ST. DEV. =      0.306
                            m  Samples +---------+---------+---------+---------+---------+---------+
Birch Bay, NPS         -0.3 to 0.1 10       I****I****I
Beckett Point, Strait      0.0      3      I********I*******I
Jamestown, Strait          0.0      3                    I********I*******I
Webb Camp, SJI            -0.3      4                  I*******I*******I
Westcott Bay, SJI         -0.3      4                      I******I*******I
Birch Bay, NPS          0.2 to 0.6  6      I*****I*****I
Beckett Point, Strait   0.3 to 0.6  4              I*******I*******I
Jamestown, Strait       0.3 to 0.6  7                  I*****I****I
Webb Camp, SJI             0.6      6                                I*****I*****I
Westcott Bay, SJI          0.6      4                                 I******I*******I
Fidalgo Bay, NPS        0.5 to 0.6 12               I****I***I
                                       +---------+---------+---------+---------+---------+---------+
                                 log10(count+1)0.00      0.40      0.80      1.20      1.60      2.00
                                    count      0         2         5        15        39        99
```

```
                                                         Glycinde picta
          Site            Elevation  # of   POOLED ST. DEV. =      0.218
                            m  Samples +---------+---------+---------+---------+---------+---------+
Birch Bay, NPS         -0.3 to 0.1 10   I****I*****I
Beckett Point, Strait      0.0      3        I*********I*********I
Jamestown, Strait          0.0      3            I*********I*********I
Webb Camp, SJI            -0.3      4                               I********I********I
Westcott Bay, SJI         -0.3      4          I********I*******I
Birch Bay, NPS          0.2 to 0.6  6   I******I******I
Beckett Point, Strait   0.3 to 0.6  4            I*******I********I
Jamestown, Strait       0.3 to 0.6  7    I*****I******I
Webb Camp, SJI             0.6      6         I******I******I
Westcott Bay, SJI          0.6      4               I*******I********I
Fidalgo Bay, NPS        0.5 to 0.6 12                  I****I****I
                                       +---------+---------+---------+---------+---------+---------+
                                 log10(count+1)0.15      0.40      0.65      0.90      1.15      1.40
                                    count      0         2         3         7        13        24
```

Figure 27 (continued)





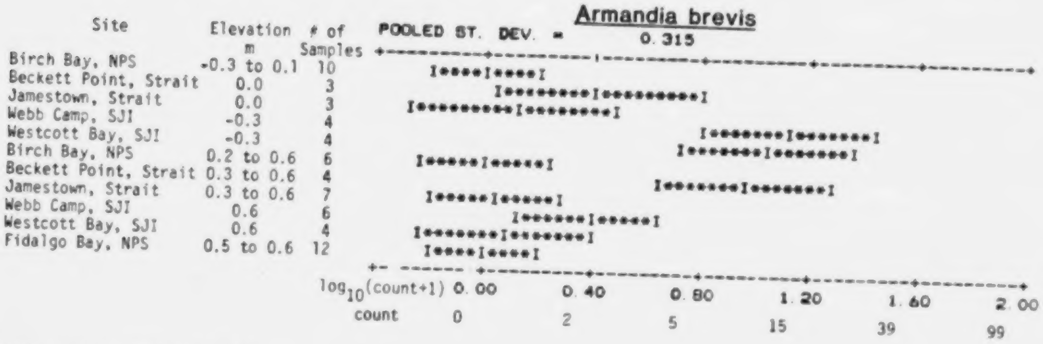


Figure 27 (continued)

they are private beaches. All of these factors may contribute to their similarly larger populations of bivalves.

Finally, even within the limited range of elevations considered there is some evidence of elevation effects. For example, *Pseudopolydora kempi* was found more frequently in the upper part of the range at all sites. However, site differences dominate elevation differences for all these populations.

Site differences and perhaps even some apparent elevation differences are at least partially a reflection of the spatial patchiness of even these most ubiquitous species. As we will see in the next section, they exhibit temporal patchiness as well. Both sorts of patchiness make prediction of population parameters difficult if not impossible.

6.2.3 Predictive models

As noted in earlier sections, we concluded that the analysis of variance approach yielded the most fruitful predictive models supportable by the existing data base. Many significant site-to-site differences were detected by analysis of variance even within a given habitat type, and elevation and season differences were also significant in many cases, implying that the best predictor for assemblage parameter values at a given site, season, and elevation would be a previously determined mean value from the same site, season, and elevation.

Cross-site prediction within a well-defined habitat type and geographical area sometimes appeared to be possible. For example, the protected Westcott Bay sites were similar to each other. The moderately exposed sand sites Eagle Cove and North Beach were similar to each other at some seasons and elevations.

To verify predictability of assemblage parameter values at a previously observed site from its past or from a similar nearby site, an attempt was made to predict Eagle Cove high intertidal data for the summers of 1977 and 1978 on numbers of taxa and individuals. These data were available in Nyblade (1979b) and had not been used for model development.

We hypothesized that mean values of S_a computed from earlier summer high intertidal samples at Eagle Cove and North Beach should be good predictors of the 1977 and 1978 Eagle Cove values. We also tried predicting $\log_{10}(N_a+1)$ although we expected it to be less predictable since among the assemblage parameters computed at soft substrate sites, N_a most often exhibited spatial and temporal variability.

The vehicle for assessing whether the indicated mean values were in fact good predictors was a test for difference in mean or median values using the old and new data. We used both the two-sample *t*-test and the Mann-Whitney test since the latter is valid even if the old and new samples are not normally distributed with equal variances.

Testing at the 5 percent level, no significant differences were found between values of S_a at Eagle Cove in either 1977 or 1978 and those computed from either 1976 Eagle Cove data or combined 1975 and 1976 data. S_a computed from either 1977 North Beach data or combined 1976 and 1977 data from that site was also not significantly different from the 1977 or 1978 Eagle Cove values. The means were indeed good predictors for S_a.

In comparing counts, the Eagle Cove data from 1976 alone did not show significant differences from the 1977 data, but both the *t*- and Mann-Whitney tests were significant at the 5 percent level when the 1975 and 1976 Eagle Cove data combined were compared with the 1977 data. Neither the 1977 North Beach data nor the combined 1976 and 1977 data yielded values of $\log_{10}(N_a+1)$ which differed significantly from those at Eagle Cove in 1977. However, significant differences between $\log_{10}(N_a+1)$ at Eagle Cove in 1978 and the pre-1977 values at both sites were indicated. The 1977 and 1978 Eagle Cove values did not differ significantly.

The methods used for assessing the predictability of assemblage parameters at the moderately exposed sand sites were also applied to the protected mud sites Westcott Bay and Fidalgo Bay. Summer 1978 data from both sites as well as 1977 data from Westcott Bay were available in Nyblade (1979b). The earlier samples with which they were compared were those included in the analysis of Figure 24. This analysis had included two replicates at -0.3 m and one at 0.6 m at both Webb Camp and Westcott Bay, so for both 1977 and 1978 we included the three available samples at -0.3 m and the first two at 0.6 m from Westcott Bay. At Fidalgo Bay we had three replicates at 0.5 m in both 1976 and 1978. We tested at the 5 percent level, so there is a high probability of one or more false rejections among the multiple tests.

Site-specific predictions of S_a were possible at both Westcott Bay and Fidalgo Bay, and the 1976 Webb Camp data were also usable for predicting S_a at Westcott Bay in 1977 and 1978. Animal diversity H'_a was similarly predictable. However, the *t*-test detected significant differences in animal counts in the site-specific predictions of summer 1978 from 1976 data. In fact, as we would certainly not expect from Figure 24, 1978 Westcott Bay data were better for predicting 1978 Fidalgo Bay data than were the 1976 Fidalgo Bay data.

Nyblade found larger numbers of species and individuals in 1978 at Fidalgo Bay than Webber found in 1976. Several explanations for these differences are possible. A real increase may have occurred at Fidalgo Bay due to weather, recruitment, or other patterns. It may be that concurrent data from a site reasonably close to Fidalgo Bay geographically and in terms of habitat reflects these patterns better than two-year-old data from Fidalgo Bay. It may be that undiscovered data errors or investigator biases are contributing to the differences. It may simply be that random variability or violation of statistical assumptions of the *t*-test have led to a false rejection of the hypothesis of year-to-year similarity at Fidalgo Bay.

All the significant differences between the data of Figure 24 and the Westcott and Fidalgo Bay data of Nyblade (1979b) involved count data two years apart in time. A difference between the 1976 SJI and Strait data and the 1978 Westcott Bay data was indicated by the more generally applicable Mann-Whitney test as well as the *t*-test.

We have mentioned in earlier discussions that failure of a statistical test to detect differences is no guarantee that none exist. In order to fully assess predictability of assemblage parameters, we must examine the power of the tests being used to detect change in soft substrate intertidal habitats using the techniques discussed in Appendix A and applied to rocky intertidal data in Section 6.1.3. Table 28 gives detectable differences in soft substrate assemblage parameters analogous to those presented for rock data in Table 16.

TABLE 28. DETECTABLE PERCENT CHANGES, SOFT SUBSTRATE ASSEMBLAGE PARAMETERS

Habitat	Replicates		Probability of Detection* 0.9			Probability of Detection 0.5		
	n_1	n_2	S_a §	$\log_{10}(N_a+1)$	H'_a	S_a	$\log_{10}(N_a+1)$	H'_a
Protected mud or mixed fine, low to mid elevations, summer‡	3	3	51% (32%)	21% (17%)	49% (41%)	30% (23%)	12% (9%)	29% (22%)
	5	5	34 (29)	13 (11)	33 (28)	21 (16)	8 (7)	19 (16)
	18	3	31 (27)	12 (11)	30 (26)	19 (15)	7 (6)	18 (15)
	12	5	26 (23)	11 (9)	25 (22)	16 (13)	7 (5)	16 (13)
	18	8	21 (18)	8 (7)	20 (18)	12 (10)	5 (4)	12 (10)
	15	15	18 (15)	7 (6)	17 (15)	10 (9)	4 (4)	10 (9)
	25	25	14 (12)	5 (5)	13 (12)	8 (7)	3 (3)	8 (7)
Exposed sand, high elevation, summer†	5	5	120 (105)	136 (119)		76 (60)	85 (68)	
	15	15	63 (55)	71 (62)		38 (32)	42 (36)	
	25	25	48 (43)	54 (48)		29 (24)	33 (27)	

§ The numerical assemblage parameters included in this table are defined in Section 5.2.1.

* Probabilities of detection (0.9 in the left half of the table, 0.5 in the right half) are based on the assumption that means of the indicated numerical assemblage parameters are being compared using the two-sample *t*-test of (A.4.1) of Appendix A. The level of the test is assumed to be $\alpha = 0.05$. There are assumed to be n_1 replicates in one sample and n_2 in the other. Detectable percent changes for a two-sided test are tabulated, with values for a one-sided test in parentheses. A parameter with a small detectable percent change is usable for estimating community changes while one for which only large changes are detectable is less useful.

‡ Values of μ_1 and σ in (A.4.5) were summer 1976 means at Jamestown and pooled standard deviations from the analysis of variance of Figure 24. Jamestown means were chosen as "typical."

† Values of μ_1 and σ in (A.4.5) were summer 1977 means at the North Beach sand site, chosen as "typical," and pooled standard deviations from the analysis of variance of Figure 22.

The data in Table 28 indicate that in protected soft substrate habitats, $\log_{10}(N_a+1)$ has a smaller coefficient of variation than S_a and H'_a. With $n_1 = n_2 = 3$ the latter two parameters must change by about 50 percent to give a 90 percent probability of detecting the change. If $n_1 = n_2 = 5$ they must change by about a third instead of by half to give that probability. Relatively small changes in $\log_{10}(N_a+1)$ are detectable, so it is not surprising that the significant differences were found in this parameter.

The apparent predictability of S_a and H'_a is at least partially due to the fact that only relatively large changes in these parameters are reliably detectable. Much power to detect change is gained by collecting five instead of three samples. Power achievable by collecting more than five replicates increases more slowly with n_1 and n_2.

The changes detectable with 90 percent probability and $n_1 = n_2 = 5$ at Jamestown translate into a decrease to 23 or an increase to 46 in S_a, a decrease to 768 or an increase to 5,600 in N_a, and a decrease to 1.4 or an increase to 2.8 in H'_a.

The mean value of S_a and the value of N_a corresponding to the mean of $\log_{10}(N_a+1)$ at the exposed sites are typified by the high intertidal North Beach sand data used for the exposed sand calculations of Table 28. These values are $S_a = 3$ and $N_a = 5$. Diversities at the exposed sites are generally less than one. Thus the differences between protected and exposed sites are clearly detectable with $n_1 = n_2 = 5$. However, it is a striking feature of Table 28 that only very large changes (50 percent or more) are reliably detectable at the exposed sites even with 25 replicates in each of the two samples being compared. The apparent predictability of the numerical assemblage parameters at exposed sites is clearly due largely to high coefficients of variation which make detection of small changes at exposed sites improbable.

Table 29 shows detectable percent changes in population counts at protected soft substrate sites. The animals included in the analysis of Figure 27 were considered. Cell means and standard deviations of the 12 mid-elevation Fidalgo Bay samples were used in the calculations for all species except Armandia brevis and Transennella tantilla, which were not found in these Fidalgo Bay samples. The mid elevation Westcott Bay values were used for these two species.

It is clear from Table 29 that the level of replication in the baseline study program was inadequate for reliably detecting changes in population densities, at least at Fidalgo Bay. As suggested by the results for Transennella tantilla and Armandia brevis, the situation is sometimes better and sometimes worse when we consider the other sites. We used Fidalgo Bay values in (A.4.5) for Table 29 because the number of replicates at the other sites was much too low to provide reasonable estimates of means and standard deviations. In order to reliably assess the possibility of using a particular species as an indicator of change at a particular site, one would need to collect 15 to 25 replicates on several occasions, estimate these statistics, and calculate detectable percent changes for various values of n_1

and n_2. It seems likely that only a few species at any site could be monitored with a reasonable level of replication.

As mentioned in our discussion of rocky intertidal data, looking at groups of species (for example, trophic groups) rather than individual species might result in detectability of smaller percent changes with the same level of replication. In addition, other population parameters such as weight or percent cover which we did not examine due to data inadequacies might prove to be less variable than counts and therefore more useful as indices of population changes.

TABLE 29. DETECTABLE PERCENT CHANGES IN TRANSFORMED POPULATION COUNTS, PROTECTED MUD SITES

	Probability of Detection* 0.9			Probability of Detection 0.5		
	$n_1=n_2=5$	$n_1=n_2=15$	$n_1=n_2=25$	$n_1=n_2=5$	$n_1=n_2=15$	$n_1=n_2=25$
Eteone longa	225% (196%)	117% (103%)	89% (80%)	140% (112%)	70% (59%)	54% (45%)
Glycinde picta	106 (93)	55 (48)	42 (37)	66 (53)	33 (28)	26 (21)
Pygospio elegans	224 (196)	117 (103)	89 (79)	140 (112)	70 (59)	54 (45)
Pseudopolydora kempi	84 (73)	44 (38)	33 (30)	52 (42)	26 (22)	20 (17)
Armandia brevis	483 (423)	252 (221)	191 (171)	302 (242)	151 (127)	117 (97)
Capitella capitata	128 (112)	67 (59)	51 (45)	80 (64)	40 (34)	31 (26)
Macoma nasuta	196 (171)	102 (90)	77 (69)	122 (98)	61 (51)	47 (39)
Transennella tantilla	8 (7)	4 (4)	3 (3)	5 (4)	3 (2)	2 (2)
Corophium	142 (125)	74 (65)	56 (50)	89 (71)	44 (37)	34 (28)

* Probabilities of detection are based on the assumption that means of $\log_{10}(\text{count}+1)$ for these animals are being compared as in Table 28. Detectable percent changes for a two-sided test are tabulated, with values for a one-sided test in parentheses. Values of μ_1 and σ in (A.4.5) were cell means and standard deviations from mid elevation summer 1976 data included in the analysis of Figure 27. Cell means and standard deviations of the 12 mid elevation Fidalgo Bay samples were used except for *Armandia brevis* and *Transennella tantilla*, which were not found in these Fidalgo Bay samples. The mid elevation Westcott Bay values were used for these two species.

6.2.4 Summary of the Prognosis for Assessing Changes in Community Structure at Soft Substrate Intertidal Sites

Seasonal and year-to-year similarities in soft substrate intertidal communities, defined by abundance of 50 major plants and animals, were often high for a given site and elevation. However, similarities among sites were less than 25 percent in many cases and even stations from the same site and elevation stratum sometimes exhibited similarities in this range. Similarities of 50 percent or more generally occurred only between sites with similar substrates, although "sand" and "gravel" sites fell into the same clusters in some cases. Elevation effects were less significant than at rocky sites, with clusters often consisting of stations from all elevations at a given site. Similarities of 75 percent or more involved stations from the same location and the same or adjacent elevation strata except for a few predominantly exposed gravel site groupings.

The most pervasive influence on species composition in soft substrate intertidal habitats of the inland waters of northwestern Washington appears to be "exposure," a complex combination of factors including wave energy, sediment stability and water retention characteristics, and seasonal wind and current effects. Mixtures of sand and gravel are not good indicators of exposure, expecially along a geologically young coastline where coastal processes have not had a sufficient period of time to rework newly exposed sediments. Thus, mixed sediments commonly occur in both protected and exposed areas, and "sand" and "gravel" sites which are similar in terms of exposure have similar biological communities. However, the percent of fine (silt size or smaller) sediment is a function of exposure and a major determinant of biological richness.

Analysis of variance of numerical assemblage parameters at exposed sand and gravel sites pointed to a division between a moderately exposed group of sites representing the eastern end of the Strait, Whidbey Island, and San Juan Island and a highly exposed group containing most of the Strait sites and West Beach on Whidbey Island.

In the moderately exposed group, elevation effects were strong, with high elevation assemblages resembling the assemblages at the more exposed sites and the low elevations being richer. The sand sites in the group, North Beach in the Strait and Eagle Cove on San Juan Island, were quite similar, unlike the gravel sites, Ebey's Landing and Deadman Bay. Deadman Bay (SJI) had more animals than Ebey's Landing (Whidbey) and showed a less significant winter decline in richness, probably as a result of exposure. The San Juan Island sites are probably the least exposed of the exposed sand and gravel sites.

In the highly exposed group, elevation effects and year-to-year differences were generally insignificant. Site differences in the assemblage parameters were less significant than those indicated by cluster analysis because S_a and N_a, unlike the similarity indices used for clustering, are not affected by whether the few animals found in samples at two different sites represent the same or different species.

There were indications of differences due to substrate among both the moderately and highly exposed sites, but these, like geographic differences, were difficult to separate from elevation and exposure effects.

Regression analysis and analysis of variance of numerical assemblage parameters at protected soft substrate sites pointed to the same conclusions as cluster analysis. Site differences, only partially explained by habitat definition according to substrate, dominated the variability. Exposure and/or geography as well as substrate characteristics contributed to these site differences. For example, the moderately protected NPS sand site (Birch Bay) and gravel site (Guemes Island) were poorer than the most protected sites such as Westcott Bay (SJI). Birch Bay and Guemes Island, like Deadman Bay, also appeared to be quite different from more exposed sites, pointing to the conclusion that their use for predictions which are not site-specific is precluded. Highly significant differences were indicated between Strait sites and those in more protected waters (NPS, SJI).

Elevation was a highly significant factor at protected SJI and Strait sites, sometimes outweighing site differences in importance. However, elevation was relatively unimportant at Birch Bay, Guemes Island, and Fidalgo Bay, all NPS sites. The most significant "elevation" effects were at sites where substrate characteristics changed greatly with elevation.

No species were found with sufficient regularity at exposed soft substrate sites to permit population analyses. No plant species were found consistently even at protected sites. Analysis of variance of abundances of the few animal species (polychaetes, bivalves, and the gammarid amphipod _Corophium_) found most regularly at the most protected sites indicated that the level of replication used in the baseline study program was inadequate for reliably detecting changes in population densities. In order to have a 90 percent probability of detecting even density changes of 50 percent or more in most of these species, 15 to 25 replicates at a given site, season, and elevation would be needed. The prognosis for cross-site prediction is extremely poor since the analysis indicated obvious site differences not explainable by available information on sediment composition and exposure.

The level of replication required for reliable detection of changes in assemblage parameter values at exposed soft substrate intertidal sites is comparable to that required for population parameters at protected sites--25 replicates to reliably detect changes of 50 percent in number of animal taxa S_a or transformed animal count $\log_{10}(N_a+1)$. Nevertheless, detectable differences in $\log_{10}(N_a+1)$ were observed when 1978 Eagle Cove data were compared with pre-1977 data from Eagle Cove and North Beach, a similar exposed sand site.

Smaller changes--around 30 percent in S_a or diversity H'_a, 10 to 15 percent in $\log_{10}(N_a+1)$--could be detected with five replicates at protected mud or mixed sites. Differences between values of these parameters at protected and exposed sites were clearly detectable. In addition, some analyses indicated differences within the most protected site group, particularly in $\log_{10}(N_a+1)$, even between sites which were most similar in terms of substrate, for example the mud sites Westcott Bay and Fidalgo Bay.

Differences in assemblage parameter values at a given protected site within and between seasons and from one year to the next were usually insignificant, particularly if spring samples, which exhibit more variability than data from other seasons, were eliminated. More significant differences were detected in samples taken two years apart.

The assemblage parameters S_a and H'_a at protected soft substrate sites appear to be most useful for prediction and change detection. However, cross-site prediction of these parameters requires better habitat characterizations, especially with regard to exposure, than those of the present data base. Cross-regional predictability (for example, prediction of parameters at an NPS site from those at a Strait site with similar sediment and exposure) appears problematical. The present data base does not permit the clear separation of regional effects from differences in sediment and exposure or investigator biases.

Real changes in animal counts occur with time at protected as well as exposed sites, so neither site-specific nor cross-site prediction of animal density appears to be possible especially when it is necessary to predict more than a year into the future. There appear to be year-to-year dependencies in abundance, but many more years of baseline data would be needed to determine whether there are real temporal patterns which could be captured by predictive time series models such as the ARMA models of Box and Jenkins (1970). As in the rocky intertidal, statistical analysis alone would not be able to determine that an oil spill or other perturbation was responsible for a change in counts of all or particular animal species.

6.3 INTERTIDAL COBBLE SUBSTRATES

In Appendix C we list the animals and plants found at the cobble sites shown in Table 1. The Appendix C listing gives the number of samples in which each plant or animal was found at each site, sampling date, and elevation stratum.

No further analyses of intertidal cobble data were carried out due to the problems with the data outlined in Section 4. The differences in sampling techniques between investigators and studies were more severe in the cobble intertidal habitat than in rocky and soft substrates, so it would have been difficult to make appropriate comparisons of sites and times. In addition, correction of the errors in taxonomic codes, plant weights, and other data would have been extremely time-consuming. It was felt that the time was better spent on analysis of the other habitats since they represent a larger fraction of the shoreline in the inland waters of northwestern Washington. Gardner (1978) estimates that cobble habitats make up only 20 percent of the shoreline in the SJI and NPS study regions.

6.4 SUBTIDAL SUBSTRATES

Subtidal data from the 23 sites shown in Table 7 at the elevations indicated in that table were available on File 100 tapes; 1,448 different plant and animal taxa were identified in these samples. Subtidal sampling dates at each of the sites are given in Table 1. Locations of these subtidal sites as well as the sites sampled by Smith (1979) are shown in Figure 2.

As indicated in Section 4.1.2, both Nyblade and Webber sampled 0.25-m^2 quadrats on subtidal rock. However, sampling techniques on subtidal soft substrates were not at all consistent. Webber employed airlift scrapes and cores, while Nyblade used a 0.03-m^2 van Veen grab sampler at SJI sites and a 0.1-m^2 van Veen in the Strait. The assortment of methods used varies in efficacy for collecting animals and plants of different sizes as well as producing samples of differing areas and volumes. These discrepancies make quantitative comparisons of data from the different studies extremely difficult. In addition, there were serious errors in the subtidal data sets on File 100 tapes. We corrected many of these errors. However, errors in gear codes and sample numbers in the NPS subtidal data made it impossible to assign correct counts and weights to correct sampling methods and replicates. Quantitative analyses of the NPS data cannot be carried out until corrected tapes are produced by the investigator.

6.4.1 Community analyses

Tabulations of plants and animals found at different sites, times, and elevations were computed from the subtidal data. In addition, qualitative cluster analyses were performed for various data subsets. Computation of numerical assemblage parameters, regression analyses, and analyses of variance could not be carried out due to the problems discussed in the previous paragraph, and even qualitative analyses may be influenced by the differences in subtidal sampling techniques. However, cluster analysis produced some interesting results.

The complete subtidal taxonomic dictionary (Table B-3 of Appendix B) was screened to two levels for cluster analysis. The subset of plants and animals used in most of the following discussions and starred in Table B-3 comprised 50 of the more commonly encountered or representative taxa (mostly to specific level). The longer list included 132 commonly occurring taxa; the animals and plants added to obtain this list are marked with a plus sign in Table B-3. As we will see below, dendrograms computed from the same stations using the two lists did not differ dramatically.

The subtidal data base was examined from two principal viewpoints. First, we considered all sites at fixed depth strata (shallow, defined as above 5 m; mid, 5.0 to 7.5 m; and deep, below 7.5 m). Second, we looked at sites within a geographic region across the depth gradient. Data on subtidal substrates, summarized in Table 7, permit detection of segregation patterns based on substrate type within the dendrograms. Table 30, which indicates the number of plant and animal taxa found at each subtidal station, is also helpful in interpreting the cluster analyses.

TABLE 30. NUMBERS OF PLANT AND ANIMAL TAXA AT SUBTIDAL STATIONS

SITE, REGION	DATE	DEPTH	# TAXA		DEPTH	# TAXA		DEPTH	# TAXA	
		M	PLANT	ANI-MAL	M	PLANT	ANI-MAL	M	PLANT	ANI MAL
BIRCH BAY, NPS	760303	-2.0	0	42	-4.0	0	44	-6.0	0	41
BIRCH BAY, NPS	760303	-8.0	0	34	-10.0	0	40	-12.0	0	37
BIRCH BAY, NPS	760830	-2.0	0	42	-4.0	2	77	-6.0	0	51
BIRCH BAY, NPS	760830	-8.0	0	49	-10.0	0	51			
CHERRY POINT, NPS	760316	-2.0	0	38	-4.0	0	38	-6.0	0	50
CHERRY POINT, NPS	760316	-8.0	5	54	-10.0	2	52	-12.0	10	55
CHERRY POINT, NPS	760909	-2.0	4	68	-4.0	0	70	-6.0	0	66
CHERRY POINT, NPS	760909	-8.0	3	80	-10.0	1	37			
MORSE CREEK, STRAIT	760603	-5.0	13	59	-9.0	16	123			
MORSE CREEK, STRAIT	770607	-9.0	30	94						
DUNGENESS SPIT, STRAIT	760602	-5.0	5	24	-9.0	8	84			
DUNGENESS SPIT, STRAIT	770607	-5.0	4	24	-9.0	48	84			
BECKETT POINT, STRAIT	760602	-5.0	0	96	-9.0	0	126			
BECKETT POINT, STRAIT	770606	-5.0	2	76	-9.0	0	87			
NORTH BEACH COBBLE	760602	-5.0	52	110	-9.0	24	97			
NORTH BEACH COBBLE	770624	-5.0	65	127	-9.0	64	83			
JAMESTOWN, STRAIT	760602	-5.0	25	187						
JAMESTOWN, STRAIT	770607	-5.0	30	103	-9.0	27	127			
TONGUE POINT, STRAIT	760702	-5.0	15	64						
TONGUE POINT, STRAIT	760703	-5.0	32	73	-9.0	14	43			
TONGUE POINT, STRAIT	770506	-5.0	43	122	-9.0	37	59			
TONGUE POINT, STRAIT	770617	-5.0	31	107						
TWIN RIVERS, STRAIT	760604	-9.0	0	66						
TWIN RIVERS, STRAIT	760614	-5.0	32	113						
TWIN RIVERS, STRAIT	770622	-5.0	0	27						
PILLAR POINT, STRAIT	760603	-5.0	5	90	-9.0	8	79			
PILLAR POINT, STRAIT	770622	-5.0	0	67	-9.0	0	77			
KYDAKA BEACH, STRAIT	760603	-5.0	0	49	-9.0	0	76			
KYDAKA BEACH, STRAIT	770621	-5.0	0	51	-9.0	6	81			
WEST BEACH, WHIDBEY	770419	-1.5	0	17	-5.0	0	25	-10.0	0	45
WEST BEACH, WHIDBEY	770810	-1.5	2	22	-2.5	0	15	-5.0	12	49
WEST BEACH, WHIDBEY	770810	-7.5	5	62	-10.0	0	59			
WEST BEACH, WHIDBEY	771103	-2.5	0	25	-5.0	0	57	-10.0	2	73
WEST BEACH, WHIDBEY	780124	-1.5	0	18	-2.5	0	32	-5.0	5	40
WEST BEACH, WHIDBEY	780124	-7.5	0	49	-10.0	8	72			
WEST BEACH, WHIDBEY	780418	-1.5	0	12	-5.0	0	57	-10.0	0	65
WEST BEACH, WHIDBEY	780629	-1.5	0	14	-2.5	0	32	-5.0	0	48
WEST BEACH, WHIDBEY	780629	-7.5	0	59	-10.0	0	61			
WEST BEACH, WHIDBEY	781014	-1.5	0	24	-5.0	7	55	-10.0	0	81
WEST BEACH, WHIDBEY	790121	-1.5	0	9	-2.5	0	19	-5.0	1	48
WEST BEACH, WHIDBEY	790121	-7.5	0	57	-10.0	0	47			
PARTRIDGE POINT WHIDBEY	770430	-1.5	21	55	-5.0	17	53	-10.0	19	84

(continued)

TABLE 30 (continued)

SITE, REGION	DATE	DEPTH M	# TAXA PLANT	# TAXA ANI-MAL	DEPTH M	# TAXA PLANT	# TAXA ANI-MAL	DEPTH M	# TAXA PLANT	# TAXA ANIMAL
PARTRIDGE POINT WHIDBEY	770822	-1.5	0	3						
PARTRIDGE POINT WHIDBEY	771108	-2.5	16	72	-5.0	13	66	-10.0	17	76
PARTRIDGE POINT WHIDBEY	780206	-1.5	16	44	-2.5	16	69	-5.0	11	58
PARTRIDGE POINT WHIDBEY	780206	-7.5	15	52	-10.0	14	82			
PARTRIDGE POINT WHIDBEY	780516	-1.5	20	88	-5.0	26	101	-10.0	29	89
PARTRIDGE POINT WHIDBEY	780701	-1.5	32	133	-2.5	32	117	-5.0	37	98
PARTRIDGE POINT WHIDBEY	780701	-7.5	26	87	-10.0	29	112			
PARTRIDGE POINT WHIDBEY	781013	-1.5	25	127	-5.0	31	85	-10.0	25	102
PARTRIDGE POINT WHIDBEY	790122	-1.5	26	88	-2.5	17	119	-5.0	19	88
PARTRIDGE POINT WHIDBEY	790122	-7.5	21	86	-10.0	29	92			
EBEY'S LANDING, WHIDBEY	770428	-1.5	5	14	-5.0	2	69	-10.0	21	91
EBEY'S LANDING, WHIDBEY	770822	-1.5	8	51	-2.5	11	64	-5.0	12	74
EBEY'S LANDING, WHIDBEY	770822	-7.5	15	76	-10.0	13	93			
EBEY'S LANDING, WHIDBEY	771118	-2.5	28	83	-5.0	10	80	-10.0	18	86
EBEY'S LANDING, WHIDBEY	780213	-1.5	22	66	-2.5	16	53	-5.0	11	75
EBEY'S LANDING, WHIDBEY	780213	-7.5	19	70	-10.0	15	91			
EBEY'S LANDING, WHIDBEY	780508	-1.5	18	68	-5.0	17	85	-10.0	20	104
EBEY'S LANDING, WHIDBEY	780630	-1.5	22	61	-2.5	18	122	-5.0	24	112
EBEY'S LANDING, WHIDBEY	780630	-7.5	25	87	-10.0	26	105			
EBEY'S LANDING, WHIDBEY	781012	-1.5	29	81	-5.0	18	76	-10.0	24	115
EBEY'S LANDING, WHIDBEY	790118	-1.5	5	33	-2.5	0	20	-5.0	10	77
EBEY'S LANDING, WHIDBEY	790118	-7.5	22	76	-10.0	18	95			
SOUTH BEACH, SJI	741016	-2.5	0	24						
EAGLE COVE, SJI	741016	-2.5	0	23						
DEADMAN BAY, SJI	741016	-2.5	0	30						
POINT GEORGE, SJI	741127	-5.0	0	16	-10.0	0	18	-15.0	0	18
POINT GEORGE, SJI	750206	-5.0	0	9	-10.0	0	14	-15.0	0	26
POINT GEORGE, SJI	750311	-5.0	0	10	-10.0	0	13	-15.0	0	25
POINT GEORGE, SJI	750501	-5.0	2	14	-10.0	0	15	-15.0	0	22
WEBB CAMP, SJI	741016	-2.5	0	21						
WESTCOTT BAY, SJI	741016	-2.5	0	13						
GUEMES S. SHORE, NPS	760220	-2.0	7	45	-4.0	3	59	-6.0	3	52
GUEMES S. SHORE, NPS	760220	-8.0	7	37	-10.0	2	34			
GUEMES S. SHORE, NPS	760911	-2.0	7	45	-4.0	5	56	-6.0	4	49
GUEMES S. SHORE, NPS	760911	-8.0	6	44	-10.0	0	38			
FIDALGO BAY, NPS	760319	-2.0	2	38	-4.0	1	42	-6.0	0	25
FIDALGO BAY, NPS	760319	-8.0	0	44	-10.0	0	41	-12.0	0	48
FIDALGO BAY, NPS	760917	-2.0	1	42	-4.0	5	39	-6.0	0	41
FIDALGO BAY, NPS	760917	-8.0	0	46	-10.0	0	33			
FIDALGO HEAD, NPS	760320	-2.0	31	22	-4.0	27	45	-6.0	27	45
FIDALGO HEAD, NPS	760320	-8.0	8	59	-10.0	0	68			
FIDALGO HEAD, NPS	760917	-2.0	12	69	-4.0	13	78	-6.0	15	74
FIDALGO HEAD, NPS	760917	-8.0	3	61	-10.0	0	2			

Site relationships within specific depth strata:

Figures 28 through 31 show stations within specific depth strata. Stations from Whidbey Island are numerically dominant in these figures since the Whidbey subtidal sampling program was much more extensive than the earlier programs.

Shallow subtidal stations: The major dichotomies in the dendrogram based on 50 taxa for the shallow depth stratum (Figure 28) appear to involve site-related factors and substrate type. Group I in Figure 28 comprises NPS, SJI, and Whidbey stations between -1.5 and -4 m. Limb I-A is dominated by mixed substrates including gravel or cobble, while limb I-B includes primarily sand and mud substrates. Group II in Figure 28 consists entirely of West Beach (Whidbey) stations, mostly from a depth of -1.5 m with a sand substrate. No shallow subtidal samples were collected in the Strait.

Group I-A is dominated by stations with mixed coarse substrates from Ebey's Landing and Partridge Point on Whidbey Island and Fidalgo Head and the south shore of Guemes Island (NPS). Within this group segregation by site is fairly strong, but it appears that Ebey's Landing and Partridge Point support fairly similar flora and fauna.

Group I-B-1 consists entirely of NPS stations from depths of -2 m and -4 m with a variety of sediment types. Most of the Fidalgo Bay (mud) stations are segregated in this group, so it probably represents the most protected shallow subtidal sites. Group I-B-2 consists of stations from -2.5 m or shallower depths. The predominant substrate is sand, and most stations are from SJI or Whidbey sites.

The differences among site groups in this dendrogram are probably related largely to the effects of substrate type and exposure on the biota. Depth-related factors also appear to exert an influence. Group II, comprising mainly very shallow subtidal sand stations, is characterized by distinctly sand beach infaunal animals. Group I-B comprises a mixture of stations with sand, mud, mixed fine, and mixed coarse sediments, and generally they are deeper than those in group II. The infauna include species characteristic of deeper, truly subtidal assemblages, a fact which sets this group off from group II. In contrast, group I-A comprises stations at which the sediments are dominated by mixtures of cobble or gravel with silt or sand. The rock component imparts a degree of stability to the sediment, even at the shallower stations, so that the infaunal component is similar to that at the stations in group I-B. In addition, the rocks support typical epibenthic organisms such as plants and limpets. These epibenthic forms set the stations in group I-A apart from those in I-B, but the infauna are similar, causing these groups to remain in the same major dichotomy.

Figure 29 is the dendrogram based on 132 taxa instead of 50 for the same stations included in Figure 28. Segregation by geographic region is clearer in Figure 29. Limbs I-A-1-a, I-A-2, and I-B consist entirely of NPS stations. Limbs I-A-1-b and II-B include only Whidbey stations. SJI stations comprise limb II-A.

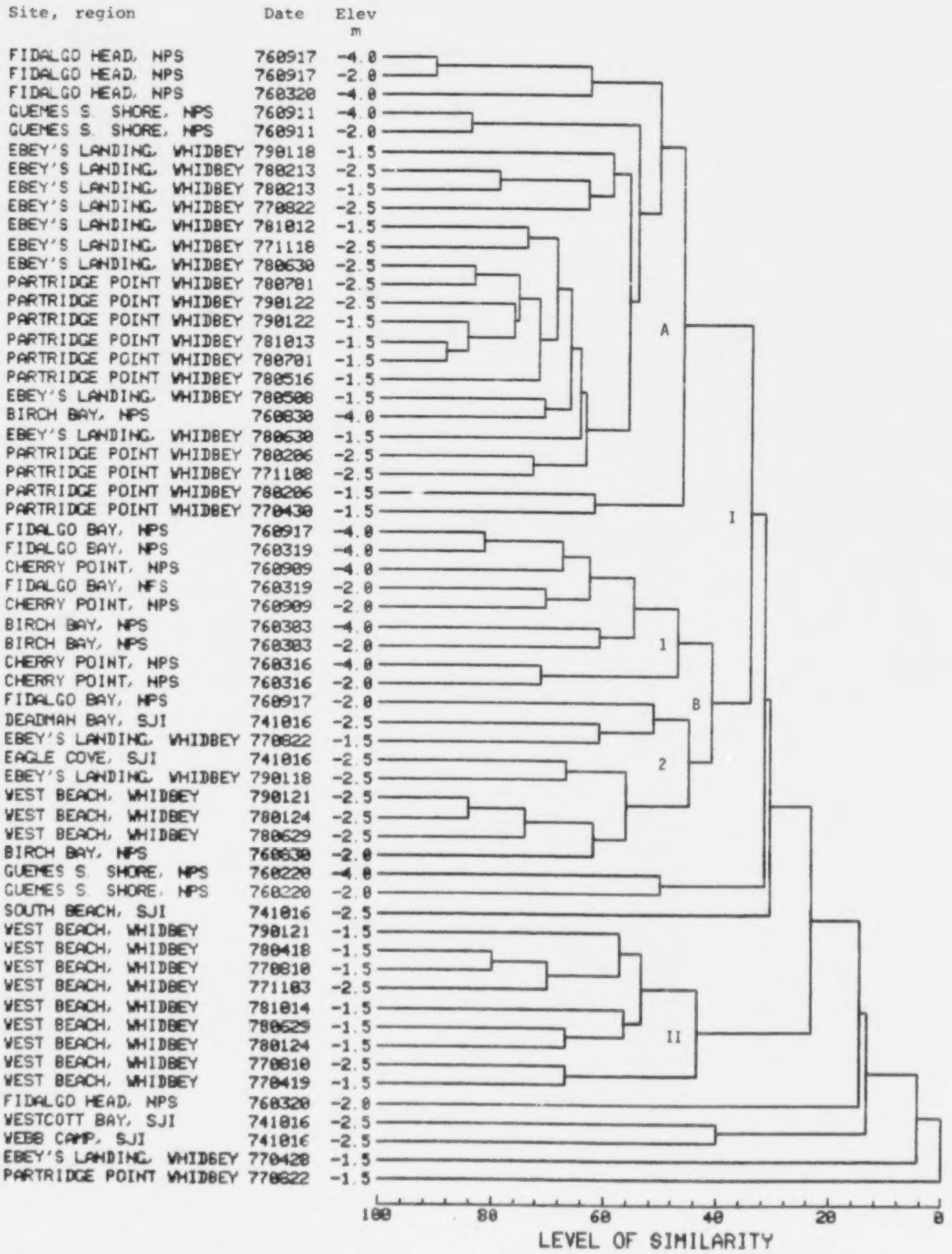


Figure 28. Relationships among shallow (above -5 m) subtidal stations based on the 50 plant and animal species or groups marked with stars in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

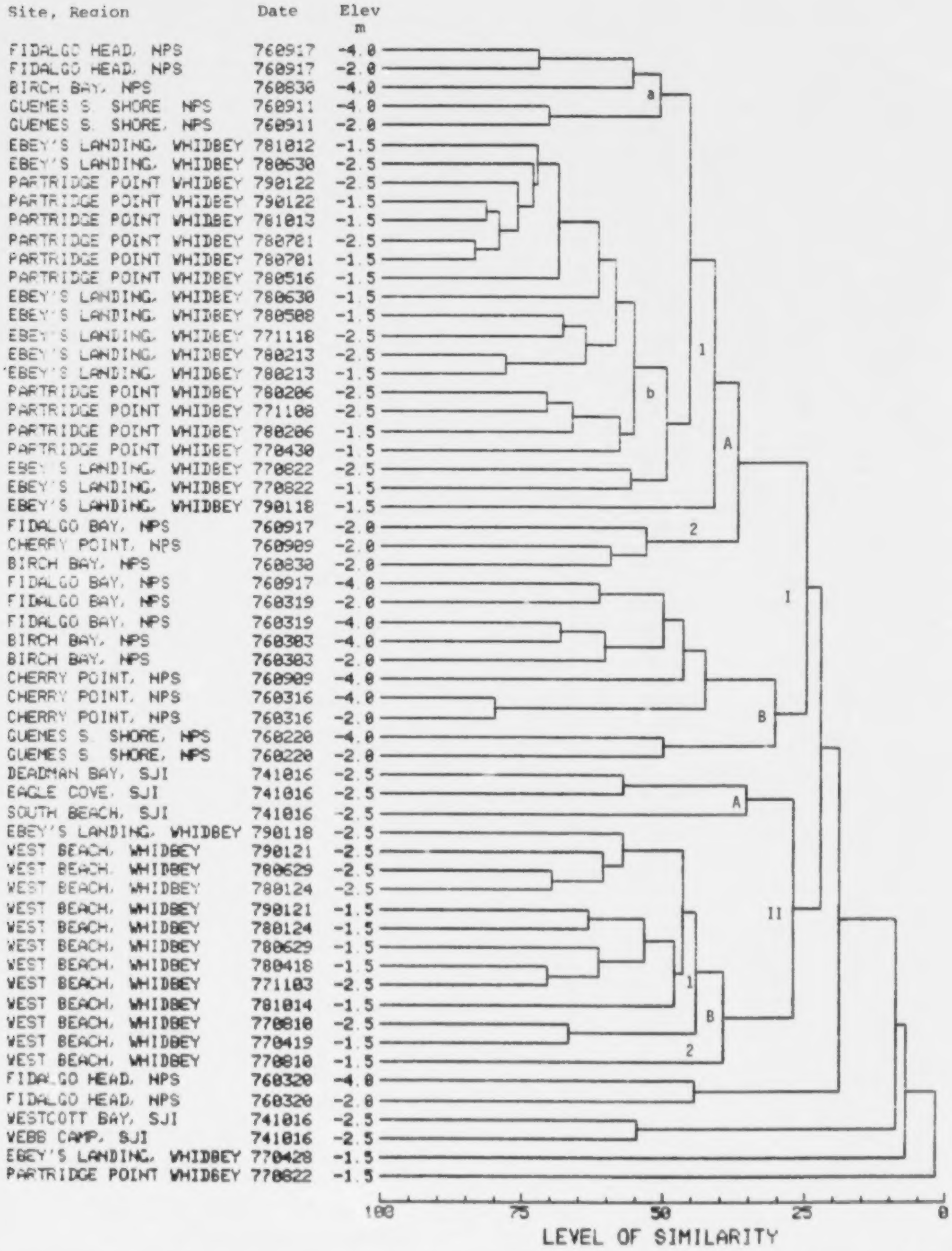


Figure 29. Relationships among shallow (above -5 m) subtidal stations based on the 132 plant and animal species or groups marked with stars or plus signs in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

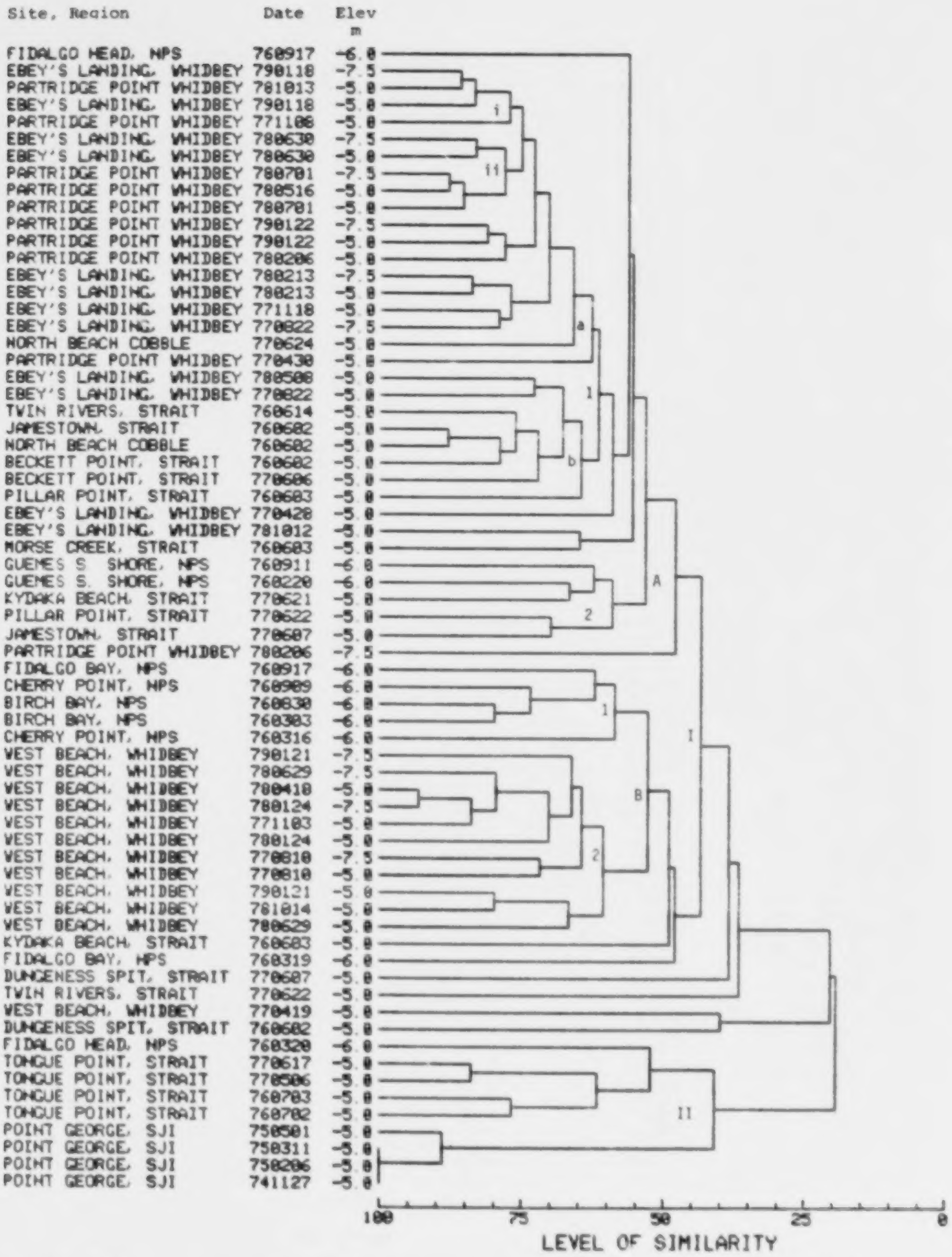


Figure 30. Relationships among medium-depth (-5 m to -7.5 m) subtidal stations based on the 50 plant and animal species or groups marked with stars in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

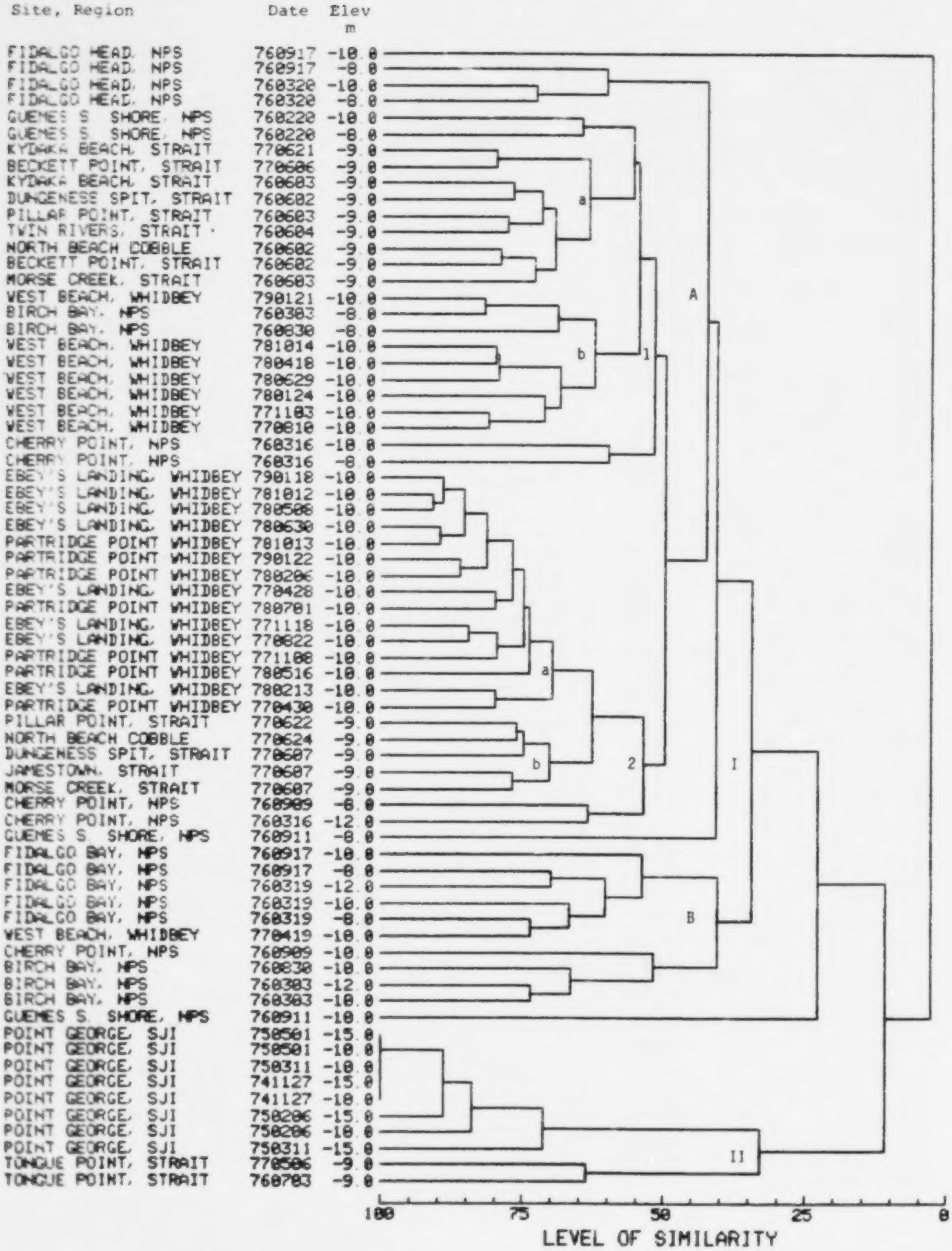


Figure 31. Relationships among deep (below -7.5 m) subtidal stations based on the 50 plant and animal species or groups marked with stars in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

As in Figure 28, group I-A is dominated by mixed coarse substrates, while group I-B includes protected sand and mud substrates, and group II is almost entirely sand. It is noteworthy that sediment analysis for the only Ebey's Landing station in group II indicated that it was sand while all the Ebey's Landing stations in group I contained cobble or gravel. Similarly, all West Beach sand stations fell into group II-B-1 while the single West Beach station which was mixed coarse according to sediment analysis comprises limb II-B-2. Thus the importance of substrate is also somewhat clearer in Figure 29.

In Figure 29 as in Figure 28, depth effects are sometimes evident, most importantly the tendency of the shallowest West Beach stations to cluster together. In many cases, however, most similar pairs of stations in both figures are from the same site and/or date and different depths.

Mid-level subtidal stations: Relationships at the middle depth stratum in the dendrogram based on 50 taxa (Figure 30) also appear to be primarily influenced by the interactions of substrate, exposure, geographic region, and other site-related factors. Group I includes stations from all regions except San Juan Island, where no mid-level or deep subtidal samples were available. Group I represents all substrates except solid rock while group II contains the rocky stations. Both groups are partitioned clearly on the basis of region and to a lesser extent by site. Within group I substrate effects are also evident, with limb I-A dominated by mixed sediments and limb I-B by sand and mud.

Group I-A-1-a consists almost entirely of mixed fine stations from Partridge Point and Ebey's Landing on Whidbey. Group I-A-1-b has a larger proportion of mixed fine and sand stations from the Strait. Group I-A-2 is harder to characterize, containing sand stations from the Strait and mixed coarse stations from the south shore of Guemes Island (NPS). Group I-B separates into limb I-B-1, containing protected NPS stations, and limb I-B-2, consisting entirely of sand substrates from West Beach (Whidbey).

Within group I-A a weak tendency to segregate by season is apparent. For instance, the survey dates for the stations in limb I-A-1-b include only the months of May through August. Limb I-A-1-a contains subgroups representing (i) fall/winter and (ii) spring/summer, each with stations from both Partridge Point and Ebey's Landing. These seasonal effects were less apparent and the tendency to segregate by site and region stronger in the dendrogram based on 132 taxa, but it was otherwise very similar to Figure 30.

Deep subtidal stations: Patterns observed in the dendrogram for stations below -7.5 m based on 50 taxa (Figure 31) are quite similar to those described for the medium-depth stratum. The major dichotomy is based on substrate type, dividing soft substrate stations (group I) from rock (group II). Segregation by substrate, site, and region within these major groups is strong. Note that Strait stations labelled as from -9.0 m in this and subsequent dendrograms should be labelled -10.0 m; the depth was incorrectly recorded on the File 100 tapes.

The mixed coarse NPS stations (Fidalgo Head and Guemes Island) and most Cherry Point stations (mixed fine, NPS) appear alone or in pairs in isolated limbs of group I-A. The remainder of this group consists of sand and mixed fine Strait stations (limb I-A-1-a), a subgroup (I-A-1-b) dominated by West Beach sand stations, mixed fine stations from Partridge Point and Ebey's Landing on Whidbey in group I-A-2-a, and another group (I-A-2-b) of 1977 Strait stations. The first Strait grouping included 1976 as well as 1977 stations and a larger proportion of sandy substrates than the second.

Group I-B, consisting mainly of mud stations, is also the largest aggregation of NPS stations. This group very probably comprises the most protected sites examined subtidally. At this deeper stratum, exposure may explain the separation between Whidbey Island and Strait stations. The Strait sites may be exposed to long period ocean swells which extend to a depth of at least 10 m, while Whidbey Island sites are seldom exposed to waves which reach that depth.

Segregation of Strait stations by year was complete in the dendrogram based on 132 taxa, but in general it was very similar to Figure 31.

Depth-site-sediment relationships within regions:

Whidbey Island, 1978-1979: Data from all depth strata occupied in 1978 and 1979 at Whidbey Island sites, were examined by cluster analysis to evaluate the relationship between depth and site effects in a fairly homogeneous geographic region with well-defined sediment types. The 1977 data were omitted to achieve a data set of convenient size.

The major dichotomy in the Whidbey Island dendrogram (Figure 32) appears to be based on sediment parameters. Group I includes only mixed fine and coarse stations whereas group II includes only sand stations. Although this division also gives the appearance of being along site lines, close inspection reveals otherwise. For instance, the one set of samples collected from Ebey's Landing that came from sand aggregated with the West Beach samples, all of which were sand, rather than with the remaining Ebey's Landing stations. Furthermore, both Ebey's Landing and Partridge Point stations occur commonly in each of the major subgroups of group I-A, which are defined mainly by sediment type. Mixed fine substrates predominate in limb I-A-1 and mixed coarse in I-A-2. It appears that each of these substrate types supports a fairly characteristic assemblage of organisms.

Within each of the major dichotomies, stations segregate fairly clearly by depth. In Group II, for example, limb II-B includes all -1.5 m stations for West Beach, limb II-A-1 includes all the -2.5 m stations, and limb II-A-2 includes all of the -7.5 m and -10 m stations. As pointed out before, the -1.5 m stations include mainly intertidal species in their lower range, creating a strong disparity between these and deeper stations where intertidal species are largely lacking. In the group including the deeper stations, the definition between depth strata becomes more indistinct.

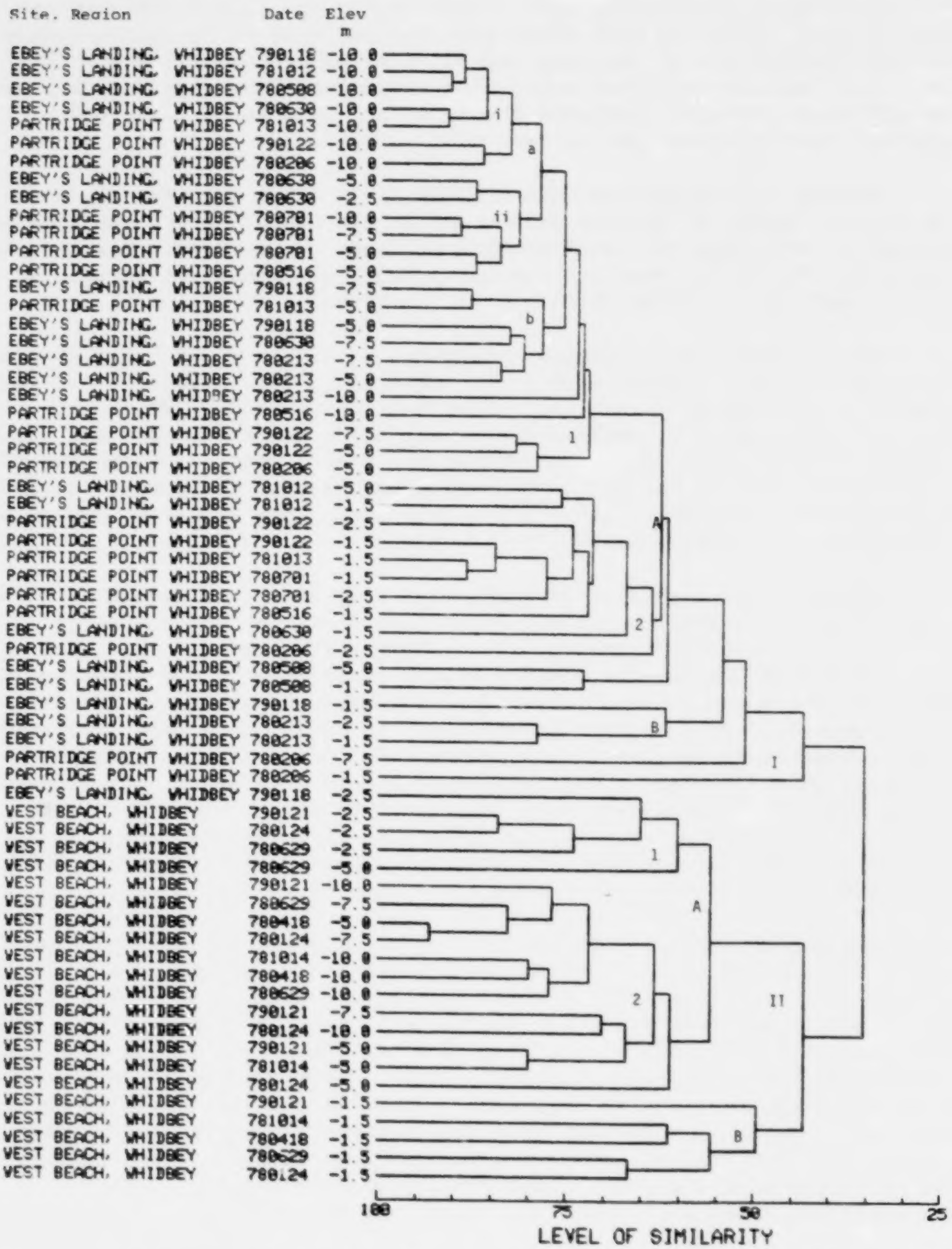


Figure 32. Subtidal depth-site-sediment relationships, Whidbey Island, 1978-1979, based on the 50 plant and animal species or groups marked with stars in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

Similarly, in group I, most of the -1.5 m and -2.5 m stations are found in limbs I-A-2 and I-B, which also include most of the mixed-coarse stations. Nearly all of the stations at -5 m, -7.5 m and -10 m are in limb I-A-1; most of these had mixed-fine sediments. The differences in rock size and depth strongly influence the types and amounts of algae and epifaunal invertebrates that an area will support.

Whidbey Island and the Strait, 1976-1977: In a like manner, stations from several depths at Whidbey Island and in the Strait of Juan de Fuca were examined to determine the relationships of these two regions. The resultant dendrogram (Figure 33) does not exhibit a major dichotomy but instead is characterized by extensive chaining (or "stairstep") at the basic levels.

The largest group, group A, comprises mainly -5 m and -10 m sand and mixed fine stations from both regions. Generally, segregation within this group is along regional lines, with limb A-1-a dominated by Whidbey stations and limbs A-1-b and A-2 consisting entirely of Strait stations. Segregation by depth is not strong, especially among the Strait stations where the most similar pairs tend to be defined by site, year, and/or substrate. However, the shallowest stations in group A all fall into group A-1-a-ii; one of these is the only mixed coarse station in group A.

Group B comprises sand stations from West Beach and Kydaka Beach, and group C comprises mixed coarse and mixed fine stations from Partridge Point. The reasons these groups are set off so sharply from group A are obscure. Group D comprises mainly the rocky subtidal sites from Tongue Point, so the reason for its strong dissimilarity from the other sites (sharp differences in substrate and, thus, biotic assemblages) is clear. The great disparity of group E, comprising shallow sand stations from West Beach, is puzzling because it shows stronger dissimilarity to groups A, B and C, all of which support infaunal assemblages, than does group D, which only supports epibenthic assemblages. One fairly clear pattern to emerge from this analysis is that the subtidal soft substrate stations in the Strait are fairly similar, i.e., they do not sort strongly by site or depth.

SJI and NPS: In a similar comparison among SJI and NPS stations (Figure 34), we see strong segregation by site and substrate across the depth gradient. Group II comprises all the rock stations at Point George, Shaw Island, and is extraneous to this discussion. Group I comprises both NPS and SJI soft substrate stations, but there are too few of the latter to permit firm conclusions to be drawn concerning them. They cluster loosely with a few isolated NPS stations to form small groupings outside of the major subgroups of group I. The remaining NPS stations define two major subgroups in group I. Limb I-A, characterized by mixed coarse sediments, includes mostly Fidalgo Head stations. Limb I-B is larger and more diverse, comprising mixed coarse, mixed fine, sand, and mud stations.

Limb I-B-1 consists of stations from all depths at Birch Bay, Cherry Point and Fidalgo Bay. Mud substrates predominate. Although the three sites frequently segregate, it seems clear that they also have strong similarities to each other. Limb I-B-2 includes chiefly mixed coarse stations from all depths at Guemes Island.

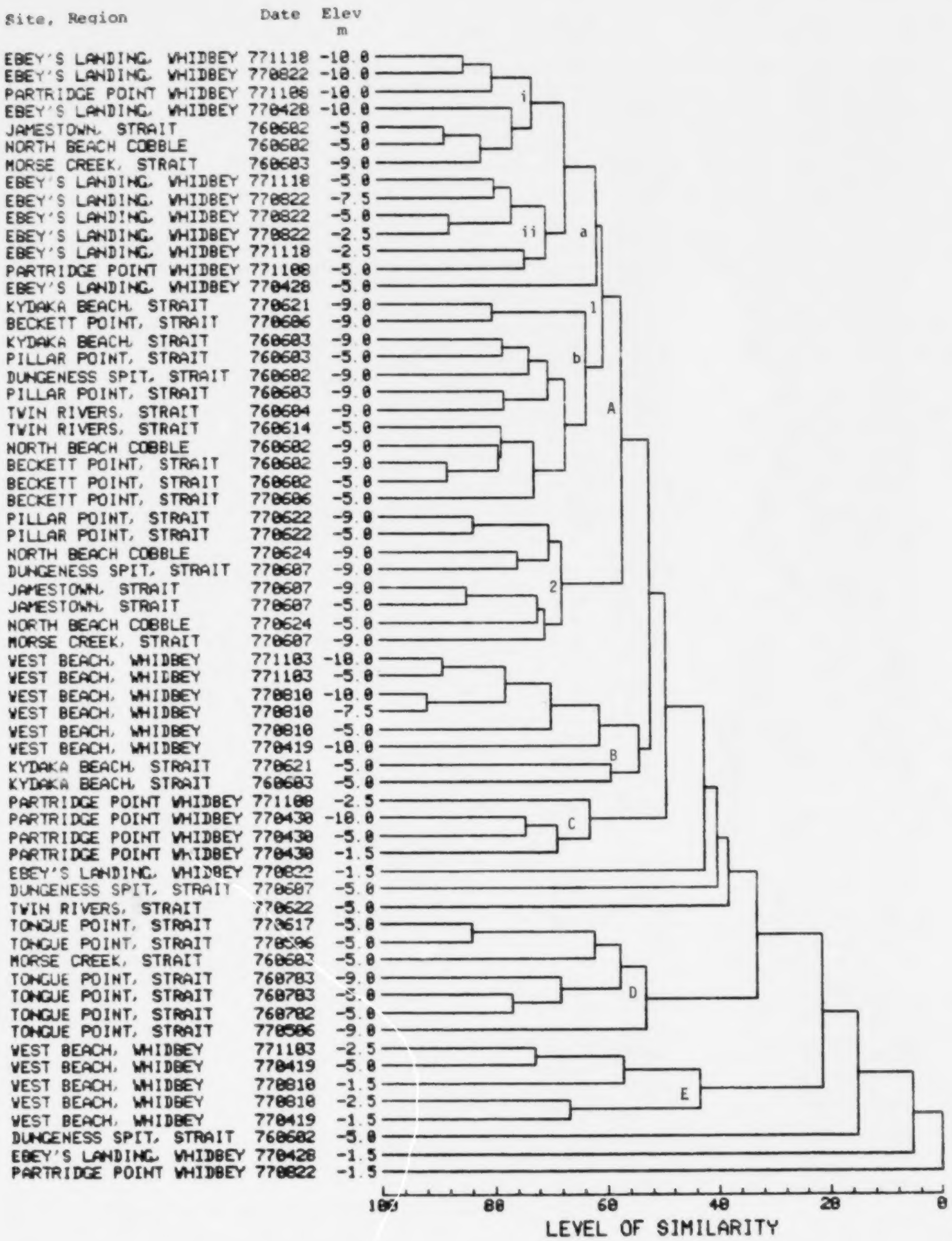


Figure 33. Subtidal depth-site-sediment relationships, Whidbey Island and the Strait of Juan de Fuca, 1976-1977, based on the 50 plant and animal species or groups marked with stars in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

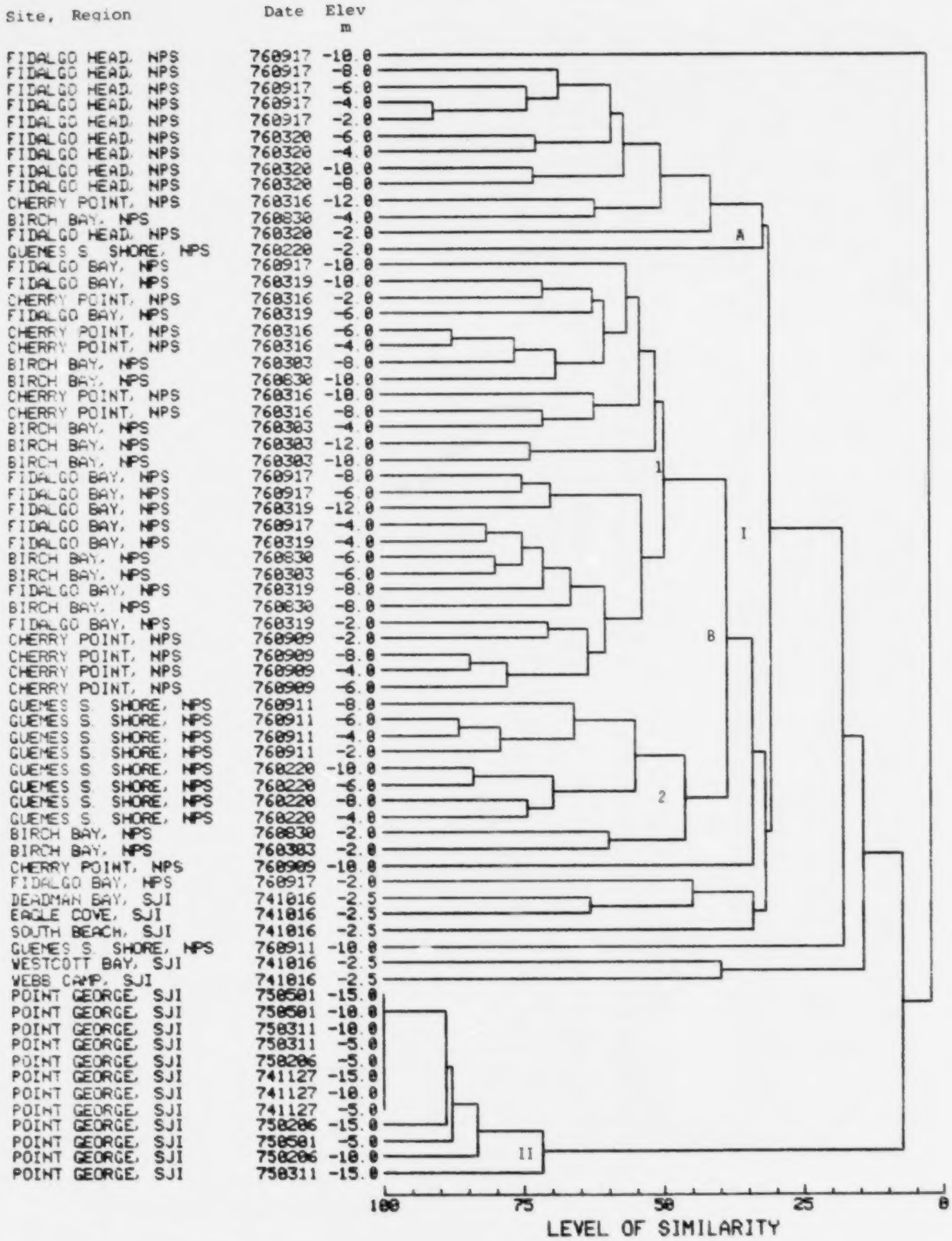


Figure 34. Subtidal depth-site-sediment relationships, San Juan Island and North Puget Sound, based on the 50 plant and animal species or groups marked with stars in Table B-3. Similarity between stations is defined by (A.5.2) of Appendix A in terms of presence or absence of these plants and animals.

The failure of the mixed coarse Fidalgo Head and Guemes Island sites to fall together in a group is somewhat puzzling. Based on the relationships of the Guemes stations, it may be that these sites differ substantially in terms of exposure, with Guemes being the more protected. This interpretation seems to agree with the geographic locations of the sites. It may also be that more precise sediment grain size data than are presently available from the sites would explain differences in their flora and fauna.

6.4.2 Summary of subtidal results

The following conclusions seem warranted on the basis of the cluster analyses. Sediment characteristics strongly influence relationships among subtidal stations with rock substrates clearly distinguished from soft. On soft substrates the presence or absence of a substantial rock component such as cobble or gravel is important. Exposure is another significant factor but the presence of cobble or gravel can override all but extreme exposure. Very shallow subtidal sites (less than -2 m) are often primarily characterized by intertidal species and thus are distinctly different from deeper stations. Depth effects become less distinct below -5 m. Mixed-coarse sediments also are uncommon below -5 m. Clustering by site occurs frequently, often cutting across the depth gradient.

Segregation by region is also strong. As in the intertidal data, regional effects cannot be clearly separated from investigator biases since all SJI and Strait samples were collected by Nyblade and all NPS and Whidbey samples by Webber. The situation is made worse in the case of the subtidal data by the fact that three different types of samplers were used--one for the SJI samples, the second in the Strait, and the third in the NPS and Whidbey sampling programs. However, neither investigator nor gear differences contribute to the separation between NPS and Whidbey sites, so it is likely that there are real regional differences, probably related to exposure.

Similarities among the shallowest subtidal stations (less than -5 m) were lower than among the deeper stations, making the prognosis for either site-specific or cross-site prediction in the shallowest depth range poor.

High similarities (mostly greater than 50 percent among stations of similar substrate) were indicated at depths of -5 m or greater, giving a better prognosis for prediction by habitat at these depths, especially within a region. The lack of strong clustering by site or depth among the Strait stations is particularly promising. It appears that the definition of habitat in terms of sediment composition is more successful subtidally than intertidally.

However, clustering by year and season in some of the subtidal dendrograms indicates that, as in the intertidal habitats, changes in communities occur naturally through time. More quantitative analyses of subtidal assemblage and population parameters are needed before final conclusions can be drawn concerning the possibility of prediction and change detection in subtidal habitats of the Puget Sound region.

SECTION 7

IMPROVED SAMPLING STRATEGIES—OBJECTIVE 2

7.1 INTRODUCTION

The second major objective of the present study was to develop a sampling strategy for future monitoring that would provide data to complement the existing data base, providing continuity with previous programs to the extent possible, thus allowing more precise predictions or extrapolations to be made for unstudied areas. Also, most importantly, the monitoring studies proposed below should increase the statistical probability of detecting real changes in the biota resulting from future environmental perturbations. The numerous and diverse statistical analyses presented in Section 6, the principal investigators' reports and recommendations, and the experience of the writers in similar studies were used to arrive at the recommendations contained in this section.

Section 7.2 provides a discussion of the kinds of parameters that can be measured or calculated to provide information about littoral benthic assemblages and species.

Three categories of recommendations are provided in subsequent subsections. The first group of recommendations (Section 7.3) applies equally to all sampling programs where repeatability of techniques, comparability of data, and ease of future data handling by persons who did not participate in the original data collection are desired. Many of these appear obvious and simplistic but are stated because, in some cases at least, they were not rigorously followed in the WDOE and/or MESA studies and have complicated the statistical testing of the data base reported in Section 6.

The second group of recommendations (Section 7.4) are those that we feel should be implemented in subsequent baseline programs in this study area. The third group of recommendations (Section 7.5) are those we feel should be implemented in post-perturbation assessments of areas affected and unaffected by some future disturbance where the goal is to statistically test the null hypothesis of "no change" from pre-perturbation conditions. Also provided in this section are additional recommendations of actions that could be initiated during a spill to get baseline information on pre-spill conditions at threatened beaches.

7.2 PERTINENT TYPES OF DATA

Some useful types of data that may be collected in monitoring programs contributing to the detection of real changes in the benthic biota, either from natural causes or acute pollution insults, relate to the assemblage and population features frequently used to describe the biota of a specific site. Types of change that can indicate a deterioration in conditions include reductions in species richness, species diversity, or biomass and serious alterations in size (age) structure or average annual density of dominant species.

The assemblage parameters include numbers of species of plants and/or animals (S, S_p, or S_a), number of discrete animals (N_a) or plants such as laminarian or fucoid kelps or sea grasses (N_p) per m^2, relative cover (percent) by plants or encrusting invertebrates, biomass of plants or animals (W_p, W_a), and species diversity for animals (based on abundance or biomass, see Section 5.2.1) or plants (based on biomass).

Useful population features include many of the same parameters, namely density (no./m^2) and biomass (g/m^2) of animals or macrophytes, and relative cover (percent) of plants and encrusting invertebrates, but each of these parameters is measured on a single-species basis. A very useful additional parameter for many species, size (or age) structure, permits evaluation of the degree of development of a species population, thus providing a clean, simple, but sensitive means of detecting subtle or gross perturbations in the environment through induced changes in survivorship curves of the species studied (e.g., Houghton 1973).

It is useful to normalize all data to the same unit of area and tabulate the data for comparison among habitats, sites, elevations, and, if applicable, major taxa. Information required for each of these parameters, their potential contribution to impact assessments, and situations or habitats in which they are pertinent are described below.

A wide range of sublethal indicators of stress to individuals is also available but is outside the scope of the baseline monitoring studies in question.

7.2.1 Assemblage parameters

Number of plant and/or animal species (S):

The purpose of defining this parameter is to quantify species richness of plants and/or animals, as appropriate. Generally, comparisons are effective only when made on the basis of a standardized sampling unit or area, such as the number of species or taxa/0.25-m^2 quadrat. If unequal areas have been sampled, comparisons of overall species richness between sites are only effective if it can be demonstrated by use of species-area curves that the sampling effort has captured most of the species present.

This parameter should be used for some component of the biota on any substrate examined. On rock and cobble substrates, it is useful to compile number of species/sampling unit separately for plants and animals, as well as a total number of species for the site. On cobble and soft substrates, it is useful to compile number of species/sampling unit separately for epibiota and infauna. Number of species has been examined extensively for the Puget Sound data base in this study, but problems arose because of sampling and taxonomic differences between investigators or regions. Only species richness values derived from a single sampling technique and from identifications of organisms to the same taxonomic levels are comparable (see Section 5.1).

Number of individual animals or plants (N):

The purpose of defining this parameter is to quantify density levels for major individual animal or plant species such as snails, starfish, and fucoid or laminarian kelps. Other types of algae and colonial or encrusting animals (sessile epibiota) are more appropriately assessed by estimating relative cover and thus should be excluded from this type of measurement. The report must, then, specify which groups have been included and excluded.

This parameter should include all readily countable and identifiable organisms above a specified size and should be used on every substrate examined. On rock and cobble substrates, it is useful to compile abundance/sampling unit separately for plants and animals as well as combined counts. On cobble and soft substrates, it is useful to compile abundance/sampling unit separately for sessile and mobile epibiota and for infauna.

A significant amount of data on density from the MESA/WDOE data set was lost because the order of sample collection precluded scaling-up of the subsample data. The sequence in which subsamples are removed from sample areas should be designed to preclude loss of data (see Section 7.4).

Relative cover (percent) by plants and encrusting animals:

The purpose of defining this parameter is to quantify the amount of surface area covered by plants and encrusting animals, thus providing a clearer idea of the nature of the assemblage and the identity of its dominant taxa. Independent estimates by two observers using a quadrat with a grid of known size (in percent quadrat area) marked on the frame should be averaged for each value recorded. Measurements are most accurately estimated in replicated quadrats and can be safely compared among specific levels at different sites with little concern over sample unit area. In areas of lush algal development, multilevel assemblages are common and thus relative cover may exceed 100 percent, even approaching 300 percent in areas supporting a surface canopy of kelp (i.e., Macrocystis or Nereocystis). This method has been used extensively in intertidal and subtidal studies in southcentral Alaska (Lees et al. 1980). Cover estimates seldom vary by more then 5 percent between experienced observers and can be assisted by providing a grid with squares of known areas within the quadrat. It is a useful adjunct to biomass and, in many instances, is the most practical and rapid way of measuring the abundance of the important algae and encrusting organisms.

This parameter should be used on rock and cobble substrates and on soft substrates supporting appreciable macrophyte populations. Although it was not generally useful in our analyses of the Puget Sound data base, if sufficient replicates are collected at a site for pre- and post-spill assessments, it can be quite useful, especially in subtidal rocky habitats.

Plant biomass:

The purpose of defining this parameter is to quantify standing stocks of plants and, within and among study sites, permit comparisons of the development of plant assemblages and an assessment of the relative importance of various major plant taxa. This is a useful adjunct to the data on plant cover. The level of detail applied to the measurement should be leavened with practicality. For instance, a large expenditure of time measuring biomass for a complex assemblage of small red algae is not justifiable; it is much more practical, and is acceptable, to measure the biomass of the aggregate, or at least separate out only the obvious dominant species.

Initially, at least, measurements of this parameter should include all removable algae; however, it is impractical to attempt to measure biomass of encrusting algae which can be best assessed by percent cover. Subsequently, assessment of the data collected may indicate that only major species or higher taxa should be sampled. Appropriate substrates are rock, cobble and soft substrates supporting appreciable macrophyte populations. Measurements should be compiled by species and/or major taxon.

Invertebrate biomass:

The purpose of defining this parameter is to quantify and permit comparisons of standing stocks of invertebrates within and among study sites. Obtaining meaningful measurements of biomass for encrusting invertebrates and infaunal molluscs is useful but a very time-consuming task because most of them have a proportionately large amount of shell material, which interferes with realistic measurement of tissue weight. However, despite this disadvantage, the parameter provides valuable insights into energy flow, secondary productivity, and resource allocation. It is a useful adjunct to data on relative cover for encrusting invertebrates. Average weight of soft-bodied invertebrates (e.g., polychaetes) is also the best indicator of their size (Nyblade, personal communication).

This parameter is most appropriately measured on rock or cobble substrate for encrusting invertebrates, and on cobble or soft substrates for infaunal invertebrates. Realistic measurements of infaunal biomass are often very difficult to obtain on cobble. As in the case of plant biomass, measurements should be compiled by species and/or major taxon, as well as by aggregate weight.

Species diversity:

The purpose of computing species diversity is to provide a parameter that integrates species richness, abundance, and the equitability with which the number of individuals is distributed among the species. Comparisons are only valid when data are based on a standardized sampling unit (e.g., 0.25 m^2 or 1 m^2.)

Although it is desirable to evaluate species diversity for all habitats, it is particularly difficult to compute a total diversity value for rock or cobble substrates because of the varied mix of parameters that are most appropriate to quantify the several components of the assemblage (e.g., percent cover, abundance, and biomass.) Biomass is probably the only common unit of measure that will accommodate the varied types of organisms, but it is also very time-consuming to measure for all groups. Thus, a more practical solution is probably to compute diversity values separately for plants, motile invertebrates, encrusting invertebrates and, in cobble and soft substrates, infaunal invertebrates. For plants the only suitable parameter for diversity computations is biomass, whereas for invertebrates either biomass or abundance can be used.

7.2.2 Population parameters

Most of the useful population parameters are collected routinely to generate the data for assemblage parameters (i.e., S, N, biomass, relative cover, and species diversity). The assemblage parameters are, in fact, a summary of the data for all species examined. Analyses of population parameters mainly involve evaluating spatial and temporal changes in abundance, biomass, or relative cover. Thus, an additional discussion of these parameters is unnecessary.

However, the size or age structure of a population is a very useful population parameter not considered above. Size structure data often provide insight into age structures of populations inhabiting different locations and are fairly sensitive to both long-term and short-term factors affecting populations. For example, short-term perturbation of mature populations may result in a noticeable change in the size (or age) structure from larger (or older) to smaller (or younger) organisms. Thus, although large numbers of recruiting juveniles may replace small numbers of adults (density increases), the change in size structure will reveal the impact of the perturbation.

Size data can be collected on most types of organisms, but good data are difficult to collect for polychaetes and non-laminarian algae. Average weight per individual can be used as a size indicator for these latter types of organisms. The size of the sampling unit is not important, but the number of measurements should be large (>300) to reduce the effects of sampling variability (i.e., improve the accuracy of the estimated mean).

7.3 GENERAL CONSIDERATIONS

It is evident from the discussions of the MESA/WDOE data base (Section 4) and our statistical analyses of it (Section 6) that several features of the two sampling programs detract from the statistical strength of the data. The general recommendations for future sampling programs provided in this section are directed at reducing obvious sources of variability evident in this and other data bases; they are in no way intended to detract from the value of the descriptive information gathered in these previous programs.

Two basically different types of sampling strategies are necessary to meet the likely needs of regulatory agencies in the study area. Monitoring studies should be conducted at strategic locations suggested by spill trajectory analyses to provide long-term information on variability in species composition, abundance, and standing stocks of important species in important habitats. Impact assessment studies would be conducted at specific impact and control sites in the event of a catastrophic oil spill. The objective of these studies is to rapidly assess the impact of a spill. Thus, the sampling strategy of an impact assessment is somewhat different from that of long-term monitoring studies.

Most of the general sampling recommendations in this section apply primarily to monitoring programs although many are equally valid for impact assessment. Because the inadequacies of the existing data bases reduce their comparability and usefulness for impact assessment, we have not been overly concerned with maintaining continuity between past and proposed studies. However, several stations previously sampled that merit continued attention are identified.

In these types of studies, emphasis should be on obtaining good information on assemblage parameters (e.g., S, N, and H') and organisms involved in major biological interactions on the specific habitat. For example, major interactions on rock involve 1) competition for "primary" space (i.e., rock surface for settling) among plants and sessile animals and 2) predation by limpets, snails, and starfish on space-dominating organisms such as algae, barnacles, and mussels. With good information on these types of organisms, investigators should be able to detect important changes in natural conditions as well as changes following an oil spill.

It should be obvious at this point, following our analysis of the MESA/WDOE baseline data for Puget Sound, that the collection of adequate data is not simple; there is no quick, easy way to get good data. The sampling replication required to "swamp out" (overcome) the natural variability (i.e., residual error) of intertidal assemblages is generally large, and budgetary planning must take this into account. If the intent is to use the data as a basis for legal action following an oil spill, the level of effort must be great enough to insure a reasonable probability of detecting a change while maintaining a low probability of falsely rejecting the null hypothesis that no change has occurred. A useful feature of the data collected that became obvious in our analyses was that smaller numbers of samples were usually necessary to detect a given level of change in numerical assemblage parameters than in population parameters of individual species. Thus, a sizable economy can be achieved by conducting full analyses on a reduced number of the replicate samples to establish estimates of assemblage parameters and examining only selected species in the remaining samples to provide adequate estimates of population parameters.

It should also be recognized at the outset that field studies alone will not establish a causal relationship though they may provide a data base to perform correlations with the effects of oil and the changes that may be observed following a spill. Such studies will only establish whether a change did, in fact, occur in the areas of impact and allow quantification of the magnitude of the change. Causal relationships can best be shown in laboratory experiments and with hydrocarbon analyses.

7.3.1 Investigators and taxonomy

To insure maximum comparability of sampling and analysis techniques from site to site, particularly within a given habitat, the same investigators should sample all sites. If this is not feasible, then at the very least, senior investigators from each group should participate in "hands-on" sampling and analysis by the other group early in the program so that techniques, field conventions, and contingencies are identical. Obviously each principal investigator must be highly experienced in the local flora and fauna and methods of identifying, sampling, and analyzing them. Finally, methods of coding, recording, and checking data must be identical.

The same taxonomic experts should be used by each group, and cross-checked reference collections are mandatory. The level of taxonomic resolution should be consistent throughout the program; i.e., if an identification has been left at the genus level early in the program, statistical analysis is only complicated by future identifications to the species level unless earlier samples are re-examined, identified to species, and the data file corrected (see Sections 4.2.4 and 5.1).

Future sampling programs should provide investigators with a current NODC taxonomic code dictionary and easy mechanisms for adding new species to this dictionary to ensure that species are consistently coded. The taxon name as well as code should appear on Species Identification records to simplify correction of errors in the code.

7.3.2 Sampling periods and duration of study

The analyses of Section 6 as well as our understanding of seasonal changes occurring in intertidal populations strongly suggest that sampling during the spring and fall is less useful than sampling during the summer and winter. Spring and fall are periods of high rates of increases and decreases, respectively, in populations of many plants and animals. Samples taken before a major recruitment of some species in the spring or before a major storm in the fall will yield vastly different results than samples taken from the same place following these events. For example, a heavy recruitment of Balanus greatly magnified the apparent differences between Pillar Point and Tongue Point during the spring of 1976. Summer and winter are times of less rapid changes in flora and fauna, reflecting more settled conditions where poor competitors have been eliminated. Thus, samples collected during these periods are more likely to indicate the real differences in assemblages between sites or years than differences in the timing of sampling within a given season.

The ideal duration of a monitoring program is difficult to assess based on the available data for this region. Under the MESA and WDOE programs four sites (Cantilever, Deadman, Westcott, Eagle Cove) were sampled at the same time of year for seven consecutive years. However, only three years of data are available on tape for any site. Other quantitative field programs in the study area (e.g., Houghton 1973, Thom 1978, Wisseman et al. 1978) have lasted only one or two years. Nonetheless, year-to-year variability seen in these data bases strongly suggests that a minimum three-year program of summer and winter sampling would be highly desirable at each site.

Subsequent verification studies each year to monitor long-term trends and to improve the data base such as those conducted for WDOE since 1976 are highly desirable. These could continue to be limited to summer sampling at a subset of the baseline sites. If there are temporal dependencies in assemblage and population parameters as indicated by the results of Section 6.2.3, these annual samples would greatly improve the credibility of any conclusions should a spill occur five to ten years after completion of the initial three years of work.

7.3.3 Sampling sites and tidal elevations or depths

The analyses of Section 6 indicate substantial biological differences among habitats that make some much more suited to monitoring studies and impact assessment than others. In fact, the biota on exposed soft substrates (sand, gravel) is far too variable to permit economic monitoring (Section 6.2.3; see Table 28); in addition, the productivity of such habitats is probably too low to warrant the expenditure.

Sites selected for monitoring should have as many as possible of the following characteristics. They should

1. be in areas with the highest risk of impact from oil spilled under present and likely future oil transportation scenarios (e.g., close to tanker or pipeline routes);

2. include areas with greatest long-term sensitivity to oil spill impacts (protected mixed, sand, and mud habitats); lesser effort should be accorded less sensitive areas (e.g., protected rocky habitats, see Chan 1977); little or no effort is justifiable in highly exposed rocky, coarse sand, gravel, cobble, or mixed habitats where the fauna is poorly developed and/or where wave energy is likely to rapidly purge oil from the beaches (Gundlach et al. 1980);

3. be readily accessible yet subject to minimal human disturbance;

4. be "typical" of as great an expanse of coastline as possible to maximize applicability of data to other sites;

5. offer a large expanse (>100 m laterally) of relatively uniform habitat in the zone(s) to be sampled.

Based on application of some of these criteria, several of the original sites examined for baseline data would be appropriate for continued monitoring. However, because all sites have not been visited by the present study group, we have not been able to explore all of the above criteria (e.g., access, expanse of beach, geographic applicability) with any high degree of reliability. Appropriate sites at risk of contamination (treatment sites) might include Jamestown, Beckett Point, Guemes Island, Fidalgo Head, Fidalgo Bay, Padilla Bay, Legoe Bay, and perhaps Birch Bay. Appropriate control sites include Westcott Bay and Cantilever Pier on San Juan Island. Note that all sites in the outer Strait of Juan de Fuca and on the west coast of Whidbey Island are generally exposed and therefore rank low by the above criteria. Other factors, e.g., very high risk of spill or lack of more suitable alternatives, might dictate inclusion of these sites.

We note that historic sampling sites are lacking in extensive areas highly susceptible to oil contamination along tanker and pipeline routes into central Puget Sound (e.g., Admiralty Inlet) and across Whidbey Island (e.g., Saratoga Passage). Since the probability of oil contamination is now, or may become, as high as it is in Rosario Strait and the Strait of Juan de Fuca, we recommend that monitoring sites be established in sensitive habitats in these areas. Useful historic data are available at Kiket Island in Skagit Bay (Houghton 1973). Other new sites appear necessary, possibly along the southern shore of Whidbey Island or the Kitsap Peninsula. We recommend a meeting of Puget Sound MESA investigators to further evaluate potential study sites for future monitoring.

To further improve the statistical strength of the data, we recommend that only one intertidal and one subtidal level be sampled, thus removing an additional variable. Sampling a single tidal level or depth would also eliminate confusion over habitat designations at sites where the substrate changes significantly with elevation. However, sampling at higher and lower zones may be desirable at particular sites or at a preselected number of sites that are particularly vulnerable to oil spills and/or contain resources of unusual value.

Several factors suggest that the appropriate intertidal level should be in the mid tide range. The actual elevation should be determined by inspection at each site so that sampling falls in the zone of maximum development for the biological assemblage characterizing that mid tide level.

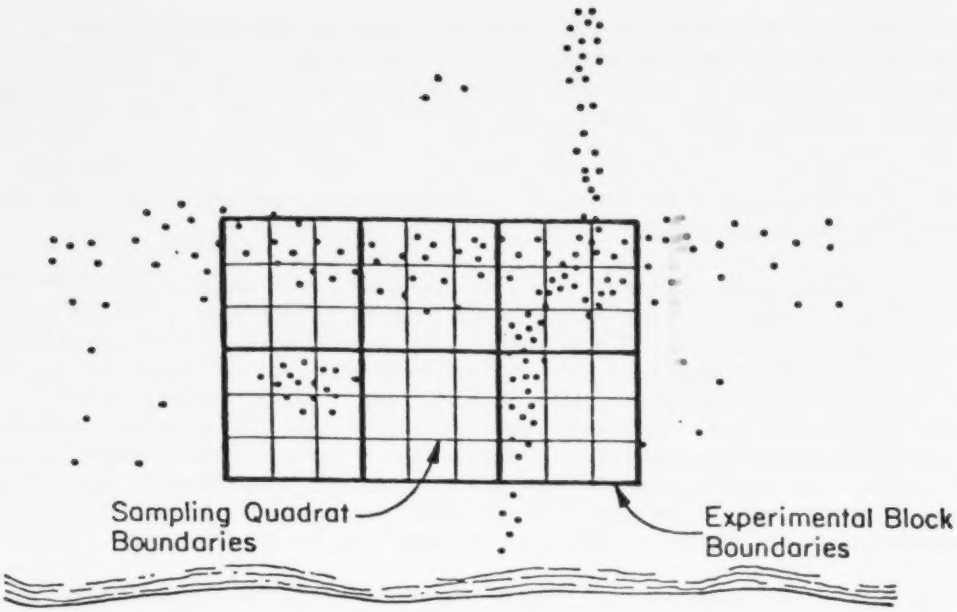
The main reasons for selecting the mid intertidal zone are that 1) probability of contamination during a spill is high, 2) the organisms here may be somewhat more vulnerable to oil effects than at higher levels (e.g., less able to "shut down" activities during extended periods of unfavorable conditions; Rice et al. 1977), and 3) the time available to work at this level is greater than at lower tide levels. Although sensitivity and resource value of dominant species at lower tide levels may be greater, many of these species are also found at the mid tide level. It is felt that the opportunity to sample on virtually every 24-hour tide cycle is overriding. In the WDOE and MESA sampling programs, there were several sites and times at which planned low elevation samples could not be taken due to wave and tide conditions. The selection is justified statistically by our analytical results indicating that the effects of elevation on uniform soft substrates are limited (Section 6.2.1).

The appropriate subtidal level is between 5 and 10 m below MLLW where effects of an oil spill on subtidal algae and invertebrates would be most acute and easily observable. Concentrations of petroleum and dispersants would be high at this depth but the effects of wave action would be less likely to remove the materials than at shallower depths. Our cluster analyses (Section 6.4.2) indicated that strictly subtidal species, often more sensitive than intertidal species (Rice et al. 1977), become common in this range. Also, similarity among sites was higher at sites deeper than -5 m. Moreover, diving activities are less hindered by buoyancy below -5 m and considerably more time can be devoted to sampling at depths above -10 m.

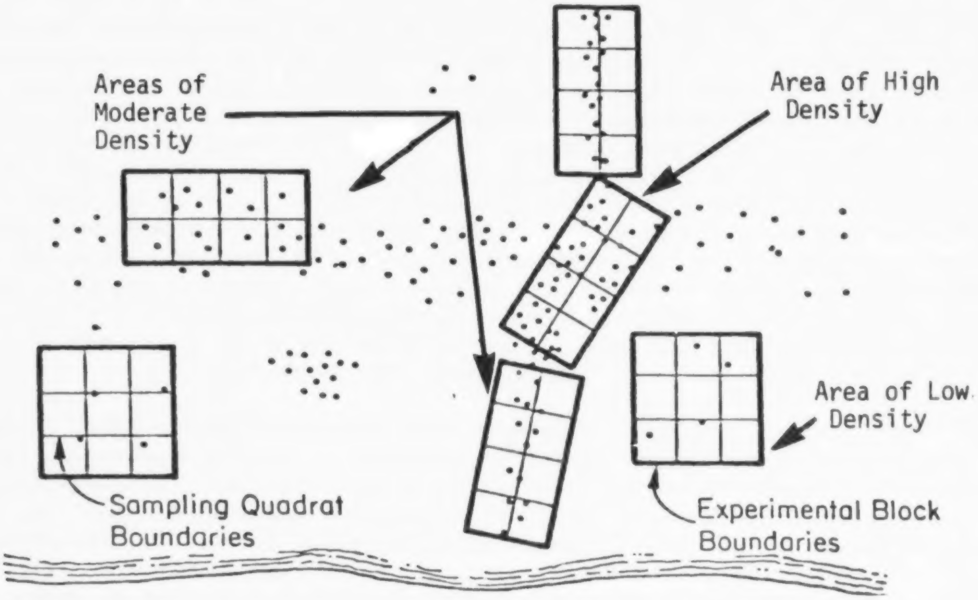
At all sites sampled, replicate samples should be collected in a doubly stratified random manner, where stratification is by general density levels for dominant organisms if practically discernible within the mid intertidal stratum (Figure 35; as suggested by Moore and McLaughlin 1978), avoiding obvious habitat nonconformities such as boulders, crevices, ridges, tidepools, etc. The purpose of this procedure is to eliminate as much cross-sample and nuisance variation as possible by logical density, assemblage, or habitat stratification and thus reduce the residual error. For example, if quadrats are placed completely randomly as indicated in Figure 35a, $\bar{x} \pm s = 174 \pm 218$ barnacles/quadrat; obviously, with 48 percent of the quadrats empty, s will be quite high. However, if the quadrat positions are initially established according to general density groups (e.g., high, moderate, and low), variance within each group would be reduced substantially (density estimates for the groups are 44 ± 48, 194 ± 101 and 450 ± 128, respectively, for the areas of low, mid, and high density). Pooling the data for all areas still provides an overall density estimate of 174 barnacles/quadrat but the probability of detecting a change in any of the given blocks is considerably higher using this technique.

Also, mid intertidal protected rocky habitats often support large, discretely distributed populations of mussels, barnacles, and algae. To sample all three of these major assemblages simultaneously produces high-variance data for all three, whereas if sampling and analysis were stratified by assemblage, within-assemblage variability would be reduced considerably, even if replication were not increased. It should be pointed out that the purpose of a baseline study is to provide information to permit detection of changes, not to characterize the assemblages.

Where the substrate is sufficiently stable, the sampling area should be well marked to permit precise relocation of the site, sampling elevation, and quadrats. Since sample collection affects subsequent data from that precise spot, a strong effort should be made to preclude resampling of a


Sampling Quadrat Boundaries
Experimental Block Boundaries

a) Regular Sampling Grid


Areas of Moderate Density
Area of High Density
Area of Low Density
Sampling Quadrat Boundaries
Experimental Block Boundaries

b) Sampling Grid Blocked According to Initial Density Levels

Figure 35. Hypothetical barnacle distribution with two alternative sampling grids. Each dot represents 100 individuals. (After Moore and McLaughlin, 1978.)

plot. To accomplish this, we suggest that the location of all projected samples be determined randomly before sampling commences and that sampling plots not be overlapping.

7.3.4 Replication

The degree of replication required to permit detection of specified changes varies considerably by habitat, numerical parameter, and species (Tables 16, 17, 28, and 29), but in most cases, it is fairly high. The purpose of continued monitoring is to provide baseline data for comparisons following an oil spill. The expected change in species richness and diversity would be a reduction. The expected change in most algae would be an increase whereas the invertebrates would initially decrease (e.g., Smith 1968). Since we can generally predict the direction of change that each parameter or species would take we can plan to use a one-sided test. This serves to reduce the replication required appreciably (see Tables 16, 17, 28, and 29).

For most parameters or species, it is probably reasonable to expect changes in mean values of at least 50 percent under natural conditions. Therefore, if we establish a sampling design so as to have a high probability of detecting changes of 50 percent, we will have a high probability of being able to detect changes resulting from an oil spill or other perturbation. Using data presented in Tables 16, 17, 28, and 29, we developed tables showing the number of quadrats or cores that would be required to permit a 90 percent probability of detecting a 50 percent reduction in the numerical assemblage parameters (Table 31) and in density of some of the dominant species in rock and soft substrates (Table 32).

For assemblage parameters, the required replication is not overwhelming except at the 1.8 m level or for species diversity. On rock, six and nine 0.25-m^2 quadrats may be adequate at the 0.0 m and 0.9 m levels, respectively, to detect reductions of 50 percent in S and $\log_{10}(N+1)$. On mud or mixed-fine sediments, three 0.05-m^2 cores may be adequate (Table 31).

For changes in average density of selected species, the situation is different; 77 percent of the species would require 10 or more quadrats to permit a 90 percent chance of detecting a 50 percent reduction (one-sided test) in density. On rock, the most favorable situation is at the 1.8 m level where six taxa can be safely assessed with 10 or fewer replicates. At the 0.9 m and 0.0 m levels, only gammarid amphipods can be assessed with 10 or fewer quadrats and the generality of this taxon makes it of limited significance for such purposes. All of the remaining species require 15 or more replicates.

These statistics show the importance of the double stratification procedure recommended above. The reduction in variance associated with density stratification should result in a useful reduction in replication.

On soft sediments, only one species of those examined would require less than 10 replicates, and more than half the species would require more than 20 replicates. However, these numbers are probably somewhat exaggerated

TABLE 31. REQUIRED REPLICATION[*] FOR DETECTION OF CHANGES IN NUMERICAL ASSEMBLAGE PARAMETERS, ROCK AND SOFT SUBSTRATES

	Plants			Animals		
	S_p	$\log_{10}(W_p+1)$	H_p'	S_a	$\log_{10}(N_a+1)$	H_a'
Rock Habitats						
Tongue Point: 0.0 m	7	<4	>25	5	<4	<4
0.9 m	9	5	>25	10	<4	13
1.8 m	>25	19	17	16	<4	20
Cantilever Pier - high	>25	--	--	15	<4	7
Soft Substrate						
Protected mud or mixed fine, low to mid-elevations	--	--	--	<3	<3	<3
Exposed sand, high elevation	--	--	--	18	23	--

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[*] Approximate numbers of replicates required to permit a 90 percent probability of detecing a 50 percent reduction in the parameter are tabled. Values are based on sampling methodology and results from the Baseline Studies Program.

TABLE 32. REQUIRED REPLICATION[*] FOR DETECTION OF CHANGES IN DENSITY OF DOMINANT SPECIES, ROCK AND SOFT SUBSTRATES

	Elevation (m)		
	0.0	0.9	1.8
Rock Substrate			
Alaria sp.	35	>50	--
Gammarid amphipods	5	9	--
Halosaccion glandiforme	--	48	--
Lacuna spp.	--	19	--
Katharina tunicata	--	41	--
Balanus cariosus	--	15	--
Idotea spp.	--	30	--
Fucus distichus	--	--	>50
Gigartina spp.	--	--	47
Endocladia	--	--	>>50
Collisella spp.	--	--	4
C. digitalis	--	--	5
C. strigatella	--	--	>>50
Littorina spp.	--	--	7
L. sitkana	--	--	8
Chthamalus dalli	--	--	6
Balanus glandula	--	--	5
Soft Substrate			
Eteone longa	45	--	--
Glycinde picta	15	--	--
Pygospio elegans	45	--	--
Pseudopolydora kempi	10	--	--
Armandia brevis	>>50	--	--
Capitella capitata	20	--	--
Macoma nasuta	47	--	--
Transenella tantilla	<5	--	--
Corophium spp.	25	--	--

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[*] Approximate numbers of replicates required to permit a 90 percent probability of detecting a 50 percent increase in log transformed plant weights or a 50 percent decrease in log transformed animal counts are tabled. Values are based on sampling methodology and results from the Baseline Studies Program.

because they are based on a mixture of sediment types and two lower elevations. Thus it should be possible to improve them considerably by restricting sampling to a specific sediment type and elevation.

In summary, we recommend that to detect reductions of the magnitude specified in assemblage parameters at unspecified sites in the area of study, at least nine replicates be examined on low or mid intertidal rock and at least three on low to mid intertidal soft substrates. We further recommend that to detect specified changes in density of abundant species, at least 20 replicates be examined initially on low or mid intertidal rock or soft sediments. The statistics can be re-evaluated subsequent to the first sampling period at a specific site and modified accordingly for later surveys.

7.4 MONITORING STUDIES

7.4.1 Sampling design for intertidal and subtidal rock

While rocky habitats are not considered the most vulnerable to long-term effects of spilled oil, there are situations where monitoring this habitat is desirable (e.g., where it is a dominant in a given area or where there are already useful data available). Several types of data must be collected to provide useful, meaningful descriptions of intertidal and subtidal rock assemblages. The size and density range of the organisms that must be examined is large (from barnacles, limpets, and littorine snails to kelps) and thus a variety of sizes of sampling units is recommended to sample efficiently and effectively and thus provide statistically useful data points for each parameter without excessive effort. Many larger organisms such as starfish, urchins, and laminarian kelps, frequently of considerable importance at lower intertidal and subtidal levels on rock, are often distributed in large patches best sampled by relatively large quadrat sizes (1 m^2, 1 m x 5 m). However, these species are of relatively less importance at many mid tide areas or may migrate downslope making them unsuitable baseline indicators. We therefore recommend continued use of 0.25-m^2 quadrats as the basic unit for rocky intertidal sampling at mid tide levels. Our recommended level of replication will allow random pooling of 0.25-m^2 data so that averages for larger sampling units can be used if examination of the data indicates that this will improve normality of distributions and result in a reduction in the range of confidence limits. A smaller subsample (0.01 m^2) is recommended for enumerating very numerous species (e.g., >100/0.25 m^2).

For subtidal habitats, a certain amount of latitude is suggested because of the great range of variability in density and biomass that will be encountered. We also suggest that plant biomass estimates be limited to laminarian kelps where they dominate because they are more stable and easier to identify. Again, it is important to recognize that the data obtained in this survey are to be used for comparisons within site rather than between sites so that the sampling area selected can be "tailored" to the site as long as the same area is used throughout.

To allow practical field identification and enumeration of organisms a minimum size of 3 mm is recommended. That is, organisms with maximum dimension less than 3 mm should not be included in any analyses. This minimum is recommended in order to permit estimation of densities of adult littorines and limpets which would otherwise be mostly unsampled. This arbitrary size limit is suggested in recognition of the necessity for some standardized lower limit. No size limit will be agreeable to all investigators.

A summary of methodology, sample units, and replication for each parameter measured on rocky intertidal and subtidal habitats is given in Table 33. For analysis, all density and biomass data should be scaled to a per m^2 basis whereas relative cover estimates apply generally to the study area sampled. The density (count) and relative cover data should be obtained directly by actual counts or visual estimates at the site.

A step-by-step breakdown of the recommended methodology for sampling rocky sites follows:

1. Establish and permanently mark with flagged stainless steel bolts both ends of a 100-m centerline parallel to the water line at the elevation(s) determined as described above. Subtidally, it is useful to mark the entire transect with a "permanent" polypropylene line to facilitate relocation. A 50-m centerline can be used if areal extent of the zone to be sampled is limited. Additional bolts may be placed if needed to insure following of the beach contour. Establish sufficient additional markers to permit relocation of the bolts. Foot traffic should be restricted to a lane 1 m wide around the centerline to reduce damage to the assemblages during sampling.

2. Lay out a 50- or 100-m tape (as appropriate) along the beach contour from bolt to bolt or along the permanent transect line. Locate randomly pre-selected cardinal number on the measured tape. Use randomized techniques to locate quadrats above, below, left, and right of the cardinal numbers.

3. Photograph labeled quadrat using color film.

4. Estimate percent cover of overstory macrophytes such as laminarians. Cut and bag all overstory species with holdfasts located within the quadrat for density and biomass estimation. Estimate percent cover of understory algae, cut and add to those already bagged. Field segregation of species or major groups into different bags may save considerable laboratory sorting time. Any animals (>3 mm) attached to portions of the fronds lying within the quadrats should be retained for later counts. Estimate percent cover of encrusting algae. In some cases, subsampling of algae (e.g., articulated corallines) may be warranted. If so, remove species to be subsampled only from the lower left-hand 0.01 m^2 of the larger quadrat. This may be best accomplished after all animals have been counted.

TABLE 33. PROPOSED SAMPLING PROGRAM, ROCKY INTERTIDAL AND SUBTIDAL HABITATS.

Organism	Parameter	Quadrat Size	Replication	Unit of Measure
1. Large Macrophytes (>3mm)	Intertidal Percent cover (visual estimate)	0.25 m^2	20	Percent
	Biomass[a,b] (scrape)	0.25 m^2	20	g wet weight per m^2
	Subtidal Density (visual count)	1 m^2 to 1 m x 5 m	20	No. per m^2
	Percent cover (visual estimate)	0.25 m^2	20	Percent
	Biomass[b] (scrape)	1 m^2 to 1 m x 5 m	20	g wet weight per m^2
2. Large Motile Invertebrates (>3mm)	Intertidal Density (visual count)[a]	0.25 m^2	20	No. per m^2
	Biomass[c] (collect)	0.25 m^2	20	g wet weight per m^2
	Subtidal Density (visual count)	0.25 m^2 to 1 m x 5 m	20	No. per m^2
	Biomass[c] (collect)	0.25 m^2 to 1 m x 5 m	20	g wet weight per m^2
3. Encrusting or Sessile Invertebrates	Percent cover (visual estimate)	0.25 m^2	20	Percent
	Biomass[c,d]	0.01 m^2	(d)	g wet weight per m^2
4. Very Abundant Species	Density and/or biomass	0.01 m^2	20[e]	
5. Key Assemblage Component Species	Size Frequency (total length, carapace length aperture size, etc.)	--	Use first 200-300 individuals collected	--

[a] Very abundant species may be subsampled as in 4.

[b] Not done for encrusting plants.

[c] Optional depending on available time and resources.

[d] For biomass of species such as barnacles and mussels see methodology in the text.

[e] Subsample one 0.01 m^2 area in the center of each of the 20-0.25-m^2 quadrats.

5. Count all invertebrates (>3 mm maximum dimension) within the quadrat (see item 7, below, for variation). Species too numerous to conveniently count (say 100 per m^2 quadrat) may be subsampled by counting only those individuals present in a 0.01-m^2 quadrat in the lower left-hand corner of the quadrat. Estimate percent cover for sessile and colonial species (e.g., barnacles, mussels, tunicates, sponges, and bryozoans). It is often appropriate to measure both abundance and cover for barnacles and mussels. If counting is too laborious for these taxa, the following method can be used: Count all barnacles in a 0.01-m^2 quadrat placed non-randomly in an area of readily estimated heavy cover (e.g., 100 percent) and use this factor to extrapolate to the number for the entire quadrat. For example, if the entire quadrat had 75 percent cover and if 0.01 m^2 of 90 percent cover had X individuals, then the entire quadrat had an estimated (0.75)(25)(X/0.9) individuals. Use the average of the number/percent ratio obtained in 0.01-m^2 subsamples from three randomly selected quadrats to estimate numbers of these species represented by the percent cover estimated in the remaining quadrat at that station. Representative specimens of questionable species should be collected for taxonomic resolution in the laboratory.

6. Where laminarian kelps and large invertebrates are common, count the large plants or invertebrates in the larger (1-m^2 or 1 m x 5 m) quadrats. Density level (and water clarity subtidally) should be considered in choosing the size of the quadrat to be employed. After enumeration is completed, the plants can be collected for measuring biomass or size. Mobile animals should be left in place as removal could affect subsequent density estimates.

7. Because of the field and laboratory time required to obtain reasonably accurate estimates of animal biomass and because density is a defensible indicator of faunal abundance, we do not recommend routine collection of biomass data because removal of animals during one sampling period could influence community structure in subsequent periods during this type of baseline program. If animal counts are being measured, biomass for many species can be estimated in the laboratory on the basis of size data, length-weight regressions, and density data.

8. Take samples of five to six key species for length-frequency analysis. Species should be pre-selected based on site reconnaissance so that collections can begin in the first quadrat sampled. To remove size bias in collection, the first 300 individuals counted in the random quadrats should be retained. Three hundred is a recommended minimum sample size for size-frequency analysis but may not always be available. It may be possible to obtain size data for some species from photographs taken subsequent to algal removal (e.g., aperture width or disc diameter of barnacles).

7.4.2 Design for intertidal and subtidal soft substrates

The three major types of data necessary to provide useful descriptions of the biological assemblages on intertidal and subtidal soft substrates are invertebrate abundance and biomass and size structure of important species. The size and density range of the organisms that must be examined, although considerable, is not as large as that observed on rocky assemblages. Thus, the variety of sampling units that must be used to sample efficiently and effectively is not as large. We recommend sampling with 0.05-m^2 and 0.008-m^2 core samplers, and 0.25-m^2 and 1 x 5 m quadrats to provide suitable samples for specified parameters (Table 34). As in the case of rock habitats, all density and biomass data should be normalized to a per m^2 basis for comparison.

TABLE 34. RECOMMENDED PARAMETERS AND METHODOLOGY, SOFT SUBSTRATE SAMPLING

Organism/Parameter	Type of Sampler	Sieve Mesh (mm)	Type of Sample	Final Unit of Measure
Large Invertebrate Abundance and Biomass	0.05-m^2 x 30 cm corer	12.5	Core	No./m^2 g wet weight/m^2
Small Invertebrate Abundance and Biomass	0.008-m^2 x 15 cm corer	1	Core	No./m^2 g wet weight/m^2
Relative Plant Cover	0.25-m^2 quadrat	--	Visual Estimate	%
Plant Abundance	0.25-m^2 quadrat	--	Count	No./m^2
Plant Biomass	0.25-m^2 quadrat	--	Removal	g wet weight/m^2
Population Size Structure	Both cores	Varies	Cores	---

The 0.05-m^2 core sampler should be used to collect data on larger, less common and deeply buried species. The sample should extend into the sediment to a depth of 30 cm, thus yielding a 15-liter sample. Subtidally, these samples are most easily collected with an air lift sampler from within a 0.05-m^2 core that has been driven into the substrate with a small sledgehammer. Since the purpose for this sample is to provide quantitative data on large invertebrates, the sieve mesh size recommended to screen the samples (12.5 mm) is the same as was used for most large core samples in the baseline studies. It will facilitate processing the large volume of sediment collected, eliminate the small abundant species, and retain the medium to large size individuals of the larger species.

To allow easy sampling and adequate replication for obtaining densities of smaller infauna we suggest using a 0.008-m^2 corer (e.g., Lees et al. 1980). The 0.008-m^2 core sampler is a readily purchased clam gun. The sample should extend into the sediment to a depth of 15 cm, thus yielding a 1.1-liter sample. With slight modifications to the standard clam gun, these core samples can be collected easily subtidally. The clam gun should be fitted with a valve to close the relief port at the closed upper end of the sampler, thus allowing suction to be maintained easily during extraction of the sample. Before commencing extraction, the sampler should be rotated rapidly and worked back and forth to break the core sample loose and allow water to flow into the hole. In addition a long cap should be fitted to the sampler with surgical tubing thongs to use in capping the sampler to preclude sample loss after extraction. Since the purpose of this sample is to provide quantitative data on small animals, the sieve mesh size recommended to screen the samples is 1.0 mm; most sand and mud will pass through this sieve, but it will retain a large proportion of the species, individuals and biomass of the sample (Reish 1959). The 1 mm size has been commonly used (as has 0.5 mm) in nearshore infaunal work. However, 1 mm will provide continuity with the existing data base and avoid some taxonomic problems and increased time required to process samples sieved with a finer mesh.

Some species will be collected in both the large and small core samples. In this case, the data set providing the highest estimate of density should be used and the other data set ignored. In no case should the data for any particular species be pooled. However, data for total animal density in the infaunal assemblage at any particular site will be obtained by combining converted density data (no./m^2) for species based on large core samples with those collected in small core samples.

On many soft substrate habitats, macrophytes (algae and sea grasses) form appreciable components. It is useful to quantify these assemblages where they are important. The same parameters should be measured as on rock, namely, relative plant cover, plant density, and biomass. Plant density and biomass of large forms such as Laminaria, should be measured with a 1 m x 5 m quadrat. A 0.25-m^2 quadrat is quite convenient for measuring relative cover and biomass of smaller, more abundant forms such as Zostera. Samples for biomass measurement should be obtained by collecting and weighing all plants with roots or holdfasts located inside the quadrat (Houghton and Kyte 1978, Lees et al. 1980). Relative cover can be efficiently measured by visual estimation in a 0.25-m^2 quadrat. This size is a satisfactory compromise between what the observer can actually comprehend in one view above and below water and what is large enough to use for kelps.

The general sampling scheme should be similar to that described above for rock. A measured centerline should be established on permanent station markers to insure accurate sample collection. In this case, care should be taken to restrict most walking and swimming to a 2-m wide traffic lane centered on the line. To randomize the position of samples, a three-digit random number should be used. The first two numbers determine a branch point on the centerline. To avoid sampling in the traffic lane, 1 m is added to the third number to determine how far away from the centerline the sample will be taken.

The size structure of important species can be determined in two basic ways, i.e., by measuring the size of standard skeletal components for animals possessing them or, for animals without hard parts, by weighing them whole. If possible, the number of animals should be at least 300, but since the specimens are to be provided by the core samples, this may not be feasible.

In any event, the number of specimens used to determine size structure should be as large as is possible since this reduces the amount by which the estimator differs from the parametric mean.

Our analyses have clearly shown the need for better characterizations of the physical habitat (Section 6.2). Therefore, in addition to the biological samples collected at each site, replicate samples for sediment grain size analysis and measurement of organic carbon and nitrogen should be collected at each end and near the middle of the centerline during each survey period. Moreover, dissolved oxygen (DO) content of interstitial water in the sediment should be measured at depths of 2, 5, 10, 20 and 30 cm in the sediment by a method similar to that described by Jansson (1968). This will permit a comparison of pre- and post-spill DO levels. Replication is necessary to reduce the effects of natural small-scale variations in sediment parameters. Oil contamination can have a severe impact on DO levels and microbial respiration, which in turn strongly influence the infauna. These samples will permit a more adequate description of natural, ambient sediment conditions and provide data for multivariate analysis.

A step-by-step breakdown of the recommended methodology for sampling soft substrates follows:

1. Establish and permanently mark with flagged steel rods (construction rebar) both ends of a 100-m centerline parallel to the water line at the elevation determined and described above. Subtidally, it is useful to mark the entire transect with a "permanent" polypropylene line. A 50-m centerline can be used if a real extent of the zone to be sampled is limited. Establish sufficient additional markers to permit relocation of the bolts. Foot and swimming traffic should be restricted to a 2-m wide lane around the centerline to reduce damage to the assemblages during sampling.

2. Lay out a 50-m or 100-m tape (as appropriate) along the beach contour from rod to rod or along the permanent transect line. Locate randomly pre-selected cardinal numbers on the measured tape. Use randomized techniques to locate quadrats or cores above, below, left and right of the cardinal number.

3. Estimate percent cover of macrophytes such as eelgrass or laminarians. Cut and bag all plants with roots or holdfasts located within the quadrat for density and biomass estimation.

4. Count all invertebrates (>3-mm maximum dimension) within the quadrat. Representative specimens of questionable species should be collected for taxonomic resolution in the laboratory.

5. Where laminarian kelps and large invertebrates are common, count them in large quadrats (1 m to 1 x 5 m). General density level (and water clarity subtidally) should be considered in choosing the size of the quadrat to be employed. After enumeration is completed, the plants can be collected for measuring biomass or size. Mobile animals should be left in place as removal could affect subsequent density measurements.

6. Where live-sieve cores and infaunal cores are collected at the same site, the latter should be collected first from a standard location outside of the live-sieve core, (e.g., at the lower right-hand corner).

7.5 OIL SPILL IMPACT ASSESSMENT

The intent of an oil spill impact assessment is to document the effects of an oil spill. Because oil spills generally involve accidents and human error or negligence, they often result in litigation or damage settlements; and, thus, it is of paramount importance that the data collected during impact assessments be accurate, pertinent and sufficiently sound, statistically and biologically, to be legally defensible. Given the amount of time usually available and the tendency for weather conditions to be quite poor at the onset of a spill (weather is often a direct or indirect cause), it is immediately apparent that the task is monumental but extremely delicate. The methods employed for impact analysis, at least initially, must be very quick and examine only the more important dominant species and the most susceptible relationships. A high degree of flexibility on the part of both sampling program and investigators is required. The investigators must be able to evaluate quickly the most valuable, germane, and sensitive resources in an area and then implement the components of the assessment program that will permit collection of a sufficient amount of appropriate data. It is thus highly advisable that impact assessments be conducted by trained scientists familiar with the geographical area in which they must operate and its ecosystems.

The time limitation dictates that priorities be established on the order in which different habitat types and biological assemblages are surveyed. It is important to survey the most sensitive habitats first and most completely. Thus, protected soft substrates and cobble or mixed-coarse habitats should be examined before protected rock habitats; exposed habitats should not be examined until satisfactory data are available for those above. Since it has been often stated (e.g., Gundlach et al. 1980) that exposed rocky habitats are most tolerant to oil contamination and recover fairly quickly (e.g., Chan 1975, 1977), there should be little concern if time (or budgetary) limitations preclude their examination. Emphasis should be on the more important (characteristic) animals and plants involved in the more important biological interactions known for each specific habitat, e.g., competition for space, grazing, and predation. On rocky substrates, particular attention should be given to plants and herbivores; whereas, on soft substrates, it should be accorded to animals constructing burrows. These particular groups exert a strong influence on the assemblages inhabiting the respective substrates and may be severely affected by oil spills.

Because of the time constraints surrounding an oil spill impact assessment, it is highly advisable to establish prior arrangements with response entities. Assessment techniques should be evaluated, tested, and reviewed and official channels of communication and contractual arrangements developed. Time lost in completing these details after a spill severely reduces the probability of acquiring satisfactory data. The response entities should be required to maintain response kits that include all of the field equipment and supplies necessary to move immediately to the scene of an oil spill and be self-sufficient.

The impact assessment program we recommend has four phases, namely:

1. Pre-oiling assessment;
2. Initial spill assessment;
3. Short-term post-spill reassessment; and
4. Recovery monitoring.

These provide a rational basis for detecting effects, evaluating the magnitude of their immediate and long-term effects, and assessing long-term contamination and recovery rates.

The techniques suggested below were selected to permit a rapid assessment of the biota. In some instances the data collected are qualitative rather than quantitative. They are a modification of a methodology developed by Davis et al. (in press) while assessing oil spill damage at several sites in the Atlantic Ocean. This methodology combines geomorphological, chemical, and biological observations to permit assessment of initial and subsequent impacts and prediction of long-term impacts and recovery rates. All but the Phase IV recovery studies are one-time surveys.

7.5.1 Pre-oiling assessment--phase I

It is generally not possible to obtain detailed information on the biota of the sites examined before they are oiled. In some cases, however, limited pre-spill data can be obtained at sites prior to oil coming ashore, or sites previously not oiled may be in the probable path of a drifting oil slick. In those instances, a strong effort should be made to collect as much data on dominant organisms at as many sites and on as many substrates as is possible. At this point in time, the only limitation to sample and data collection should be the time and money available for field efforts and not concern over existing budgetary limitations of laboratory analysis (Smith 1979). Over-sampling can be easily rectified at a later date but undersampling of pre-spill conditions is irreversible once a habitat has been oiled.

The purpose of a pre-oiling assessment is obviously to obtain data on pre-spill conditions at non-oiled sites (either control sites or sites at which oiling is projected). The goal is to determine what organisms are dominant, how many or how much, their stage of development and appearance, and the sediment and chemical conditions in the habitats prior to oiling. Besides information on the biological assemblages, the survey team should obtain abundant photographic documentation of the general appearance of each site and adequate numbers of sediment samples for hydrocarbon analysis.

Wherever possible, pre-spill surveys should resurvey nearby stations that were occupied during the baseline or monitoring studies so that they may be used to assess effects of control (unoiled) sites. As in the case of pre-spill surveys in previously unsurveyed sites, only parameters or samples that can be estimated or collected rapidly should be considered so as to maximize the amount of data that can be collected in the limited time available. The aim of resurveying old study sites is to develop an updated description of some conditions that may be used to evaluate the degree of stability of the biotic assemblage prior to the oil spill.

We assume that, in order to make most efficient use of time before a spill, most travel between sampling sites will be accomplished by helicopter. If this occurs, a useful type of data would be aerial photographs of each station on both color and infrared film. This is most effectively accomplished when the sunlight is from offshore, but in the absence of sun, light should be strong. Furthermore, photographs taken at low tide are more useful than those taken at high tide.

Upon arriving at each site, a site description sufficiently detailed to permit relocation for subsequent surveys should be recorded and permanent relocation stakes installed above the storm swash line. In addition, perspective photographs should be taken in both directions along the beach and across the beach toward the water. Construction steel ("rebar") stakes should be installed at several points along a transect across the beach at which sampling will be concentrated.

A beach profile should be developed along this transect indicating elevation change related to distance from the upper permanent relocation stake. The recommended profile method is that of Emery (1961). In conjunction with this topographic profile, the survey team should describe the associated geomorphology and biological assemblages, noting dominant structures, organisms, and assemblages and prominent changes in composition. During this procedure, numerous photographs of the biological assemblages should be taken with color and infrared film. These photographs should include detailed views of the specific subassemblages (e.g., mussel beds, barnacle encrustations, or algal turfs) that dominate the various zones.

In conjunction with the general description of the biological assemblages accomplished at each site along the profile, quantitative data describing the level of dominance by the more important species should be collected at three intertidal levels (low, mid, and high), if tide conditions permit, and one subtidal level between 5 m and 10 m.

In rocky habitats, much of the data can be collected directly. The types of data to be collected are relative (percent) cover, density (no./m^2) and size-frequency. Cover and density data for the visually dominant organisms should be recorded at each of three levels in about 20 0.25-m^2 quadrats. (This replication is based on lower Cook Inlet studies by Lees et al. (1980) since plant cover was not uniformly recorded in the MESA/DOE studies.) Efforts should be limited to species covering more than 5 percent of the rock surface or at densities greater than 10/m^2; special attention should be given to important herbivores (such as limpets, chitons, littorines, and sea urchins) and predators such as whelks (*Nucella*) and starfish. Size data should be obtained by photography for barnacles and collection of samples for mussels, limpets and littorines. All photographs taken for size measurements should be close-ups with a scale included to facilitate measurement; the level of detail should be sufficient to measure aperture length accurately to 1 mm. Several of these photographs should be taken at the relocation stakes so that they can be duplicated after the spill for comparison.

In soft substrate habitats, most of the data will be on infaunal forms and must be determined by laboratory analysis of sediment samples. Thus, most of the effort will involve collection of core samples with a clam gun (0.008-m^2) core sampler. Twenty core samples should be collected at each of three levels for infaunal analysis. Each sample should be bagged and labelled separately and preserved with a 10 percent buffered formaldehyde-seawater solution. In addition, three smaller core samples should be collected at each level for sediment grain size analysis. Finally, if burrowing organisms or algae are common in the area, about twenty 0.25-m^2 quadrats should be measured to determine burrow density and relative cover by plants. Lesser replication may be adequate for some parameters in some habitats (see Tables 31 and 32).

We believe that an important indication of the short-term conditions at a site can be determined by an examination of the shell debris and wrack in the high-tide swash line. One would expect major changes in the composition, condition, and volume of material in the swash line if a spill caused appreciable damage to the biota. Therefore, we recommend that part of any pre-spill sampling at each site be to collect all the biological material in 25 randomly located 0.25-m^2 quadrats in the high tide swash line, bag, preserve, and label each sample separately, and archive these samples for future comparisons. This effort can be accomplished during high tides and thus need not conflict with the standard sampling that is tide-limited. A severe storm between pre- and post-spill samplings can reduce the reliability of results unless spatial controls are established.

It is very useful to obtain hydrocarbon baseline information at each site to compare with existing hydrocarbon information gathered by Brown et al. (1979). The survey team should collect sediment samples at all sites for that purpose. An effort should be made to collect these samples from locations where oil would collect and be retained, e.g., under rocks and in silt pockets. It is of absolute importance that the samples be collected and stored in chemically appropriate containers so that the samples will not be contaminated. This requires considerable prior preparation and is another reason for establishing commitments before an oil spill requires sampling.

7.5.2 Initial spill assessment--phase II

The initial spill assessment, often the first survey that will be conducted at an oiled site because of the time limitations surrounding an oil spill, is quite similar in approach to Phase I. The purpose of this study is to determine the initial response of the assemblages to oil. This involves documentation of the abundance of dominant organisms as well as detection of dead, moribund, or displaced organisms and behavioral changes such as altered evasive behavior. Phases I and II surveys may be conducted concurrently at non-oiled and oiled (control) sites, respectively, in the absence of adequate time to conduct pre-spill surveys before oil starts grounding.

The methods of quantifying abundance of dominant organisms should be the same as in Phase I. Also, the types of habitats and animals selected for censusing should be basically the same. However, if organisms not previously selected for census are abundant among the casualties of the spill, an attempt should be made to document the abundance of the healthy population at both oiled and non-oiled sites if feasible. The numbers of dead and moribund organisms should be estimated with standard 0.25-m^2 quadrat techniques, as described above.

It may be desirable to collect numerous specimens or samples for examination under more suitable conditions in the laboratory so as to improve the accuracy of the taxonomic and enumeration data. As in the case of Phase I surveys, oversampling is preferable. However, if Phase I studies were possible before oiling, there is no need to expend valuable time in resurveying sites at which oiling has not occurred except to search for dead and moribund animals.

Behavioral changes in invertebrates should be measured at oiled and non-oiled sites. This can be accomplished by measuring response time of normal behavior, e.g., righting time of snails, escape time of crabs, retraction time of clams or sea anemones.

Exposure to oil should be quantified by estimating the area and thickness of oil cover in the oiled areas. Also, sediment samples should be collected from under rocks and in areas of soft substrates. Numerous samples should be collected. If possible, core samples should be divided into 2 cm thick sections to determine the depth of contamination. This is particularly important in heavily burrowed habitats such as Jamestown, where substantial quantities of oil could be captured in ghost shrimp burrows over 30 cm deep in the sediment.

As indicated above, liberal photographic documentation of conditions is extremely helpful. In areas where a pre-oiling assessment was possible, photographs should be taken at all the permanent stakes that can be relocated to permit comparisons of pre- and post-oiling appearances.

During planning sessions for clean-up efforts in the early stages of oil spills, it would be quite useful to establish several different zones to which specific clean-up methods are limited, and areas in which clean-up is not attempted. This would permit a clear design for comparing the effectiveness and suitability of the alternate methods of clean-up as well as natural recovery. Such experiments would be very useful in the selection and rejection of available clean-up technology in later spills and could avoid gross mistakes and inappropriate expenditures at later spills.

7.5.3 Short-term post-spill reassessment--phase III

Two major objectives of this phase of the study are to: 1) document the full impact of mortality resulting from the direct effects of an oil spill (combining immediate and delayed mortality), and 2) detect initial stages of recovery. Thus, the same techniques employed in Phases I and II above should be applied at previously surveyed oiled and unoiled (control) sites to determine the differences between initial and subsequent surveys due to oiling, clean-up, and recovery (at the oiled sites) and natural variation (at the control sites). A crucial component of the short-term assessment is the examination of the shell debris and wrack in the high-tide swash line. These surveys should not be conducted until at least one month following a spill but before three months have elapsed to avoid large natural changes from seasonal effects.

7.5.4 Recovery monitoring studies--phase IV

The objectives of these studies are to: 1) document rates and patterns of recovery in areas affected by oil and/or clean-up efforts and 2) attempt to determine the degree to which rates and patterns of recovery are influenced by a) recruitment rates and patterns of colonizing species, and b) residual oil and/or clean-up materials. These data would augment information on colonization of oil-contaminated sediments developed for MESA by Vanderhorst et al. (1979). These studies should be conducted concurrently with on-going standard monitoring studies which will provide important information on recruitment rates and patterns in undisturbed areas. Furthermore, the sampling techniques for the recovery monitoring studies should be identical to those for the standard monitoring studies, as contrasted with the Phase I, II and III oil spill assessment studies, except that the sites surveyed for Phase IV should be examined at low, mid, and high intertidal levels where these levels have been affected. Furthermore, as many of the "traditional" monitoring sites as possible should be used for unoiled control sites, but studies there should be augmented to provide data from the upper and lower tide zones. These studies should be conducted synchronously with monitoring studies, i.e., on a biannual basis, in summer and winter.

Two different types of studies will be required to accomplish the objectives of Phase IV studies. The standard monitoring techniques described for the monitoring studies should provide the data necessary to document rates and patterns of recovery. However, experimental manipulation will be necessary to distinguish between the effects of inhibition by residual oil and clean-up materials and natural recruitment rates and patterns on rates of recovery. Phase IV studies should commence approximately three months following the termination of clean-up activities to allow conditions to stabilize and recovery to develop. The number of sites surveyed should be limited to not more than one per treatment (untreated oiling and each major clean-up technique) on each major habitat type. This permits adequate concentration of sampling efforts and thus maximizes the results of expenditures when combined with the "control" data from the standard monitoring study. All affected and control sites studied in Phase IV should be confined to the general geographic area of the spill since our evaluation of the baseline data indicated that it is of only limited use to extrapolate between the major geographic regions of the WDOE and NOAA/MESA studies.

As part of both baseline and recovery monitoring surveys, a routine hydrocarbon sampling program should be implemented to monitor hydrocarbon levels in the dominant organisms and in the sediments. Where possible, the organisms sampled should include members of all trophic levels. Recommended groups and species in the intertidal zone include: 1) plants - rockweed (*Fucus distichus*); 2) herbivores - acmaeids; 3) suspension feeders - mussels (*Mytilus edulis*), barnacles (*Balanus cariosus*), and clams (*Protothaca staminea* or *Saxidomus giganteus*); 4) deposit feeders - clams (*Macoma*), ghost shrimp (*Callianassa* spp. or *Upogebia pugettensis*) and the burrowing sea cucumber (*Leptosynapta clarki*); and 5) predators - snails (*Nucella* spp.) and starfish (*Leptasterias hexactis* or *Evasterias troschelii*). Alternate species from subtidal habitats include *Laminaria saccharina*, *Hinnites multirugosa*, *Parastichopus californicus* and *Evasterias* or *Pycnopodia helianthoides*. Sediments should be analyzed to a depth of at least 30 cm, especially under rocks in the protected rocky or cobble areas and in soft substrate habitats that had extensive burrow systems before exposure to oil.

In addition to the Phase IV monitoring studies, we recommend that a program be implemented to partially differentiate between the effects of residual oil in a habitat and the vagaries in recruitment in the patterns and rates of recovery of previously dominant species that were extirpated by oil or clean-up operations in oiled habitats. The method of study would be to transplant test populations of selected, previously dominant species into oiled and control study areas and then monitor their success. Success can be gauged by comparing growth rates as well as survival. All trophic groups except predators should be examined.

Taxa that should be considered for transplant studies on rock habitats include rockweed (*Fucus distichus*), mussels (*Mytilus edulis*), barnacles (*Balanus* spp.), and limpets (Acmaeidae) and sea urchins (*Strongylocentrotus* spp.), all of which are readily available for collection at undisturbed sites. The attached taxa such as rockweed, barnacles, and mussels should be collected on easily transportable cobbles or small boulders and transplanted to marked locations at both the oiled and control sites. Unattached species such as limpets and sea urchins should be removed from the rocks at undisturbed sites and transplanted to marked rocks at control and oiled sites.

Taxa that should be considered for transplant studies on soft substrates include clams (e.g., *Protothaca*, *Saxidomus*, and *Clinocardium*), ghost shrimp and the burrowing sea cucumber *Leptosynapta*. The clams and sea cucumbers should be transplanted into plastic mesh boxes buried in the sediment so that they can be easily recovered periodically to census survival. In addition, growth rates should be compared between control and oiled sites. Ghost shrimp should be transported to oiled areas in which populations were destroyed and burrows are absent. At these sites, they should be protected until either they have established a new burrow or it is determined that they will not dig a new one. The locations of the transplanted shrimps should be marked and the number of remaining burrows noted on each subsequent survey.

Survival of the transplanted populations will be more of a problem to assess at the control sites where well-established populations will already exist than at the oiled sites where adults will be absent. However, it is important to assess the effect of transplant activities on survival rates of a transplant population in order to correct the observed survival rates of the transplant populations at the oiled sites. In the latter areas, all adults in the vicinity of transplants can be assumed to be introduced. However, at the control sites, the transplant populations will have to be marked in such a way as to be identifiable. In the case of rockweed and barnacles, the rocks upon which the populations were transplanted can be marked. The clams and sea cucumbers will be placed in marked plastic boxes to facilitate recovery. The greatest problems are with limpets, sea urchins, and ghost shrimp. With limpets and sea urchins the problem can be resolved by placing the transplanted populations on isolated rocks or ledges from which the resident population has been removed. For ghost shrimp, the problem of identification cannot be completely resolved but the best approach appears to be to use the collection site for the control transplant site, thus removing a large majority of the adult shrimp and effectively destroying the burrow systems over a large area. The transplant areas should be clearly marked and their positions mapped so that they can be relocated. Equal numbers of shrimp should be released in each transplant area and the numbers of burrows in each area will be used as an index of survival.

To our knowledge, transplant studies have not been utilized in conjunction with actual oil spill assessment. However, if properly controlled and designed, we believe they could potentially contribute substantially to the understanding of some of the factors influencing recovery in oiled areas and the detection of the effects of residual oil. Recruitment studies where the responses of larvae are measured would also provide important data relative to recovery and community composition.

SECTION 8

OTHER POSSIBLE APPROACHES TO ANALYSIS OF THE DATA BASE

In this section we consider other possible approaches to analysis of the data base. These fall into three categories.

First, there are a number of analyses which could be carried out using the present data base in order to further illuminate the effects on variability of the diverse sampling methodologies used in the studies. For example, subsampling variability for rock and cobble substrates could be examined via nested analysis of variance. Assemblage parameters or key community parameters could be considered in such an analysis. In addition, species-area curves could be plotted to determine the adequacy of quadrat sizes and/or number of replicates.

Second, there are analyses which could be carried out on an extended set of baseline data. A longer time span of baseline data at one or more sites would permit the use of predictive time series models such as the ARMA models of Box and Jenkins (1970). Such models may be more effective than those used in the present study for representing long-term temporal patterns in biological assemblages.

Finally, there are a number of different approaches which could be used to assess the effects of an event such as an oil spill if one should occur. Sanders (1978) suggests several statistics which proved useful in assessing the impact of an oil spill off West Falmouth, Massachusetts, on benthic fauna in Buzzards Bay. These statistics, some of which we have considered in the present study, include fidelity, coefficient of variation, and discrepancy and similarity indices. Kendall's "Tau" is a particular similarity index suggested by Ghent (1963) for examining successional changes such as those which might be expected after an oil spill. An analysis which takes into account the "distance" from the ecological event is suggested by van Belle and Fisher (1977).

Like the tests for change discussed in the present study, all these approaches are based on the availability of species-frequency lists such as those in the present data base. It is assumed that data at the sites of interest are collected after the event occurs. The resulting statistics for these sites are compared with statistics calculated from control sites sampled concurrently or earlier data from the affected sites. Certainly if a major ecological event were to occur in Puget Sound, a variety of approaches to assessing its effects should be considered. The results of the present study provide some guidelines for these approaches and for additional sampling to strengthen the baseline data which they require.

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APPENDIX A

DETAILS CONCERNING STATISTICAL METHODOLOGY

A.1 MODEL ASSUMPTIONS, DATA TRANSFORMATIONS, AND CONFIDENCE INTERVALS

Normal parametric models

Both the multiple regression and analysis of variance models, discussed in Section 5 and in more detail in this appendix, are examples of parametric statistical models. They assume that a population parameter or numerical assemblage parameter computed from a sample is an observation of a random variable Y which can be modelled as

$$Y = E(Y) + e \qquad (A.1.1)$$

where E(Y), the expected value or mean of Y, is a function of various statistical parameters and e is a random error. Observations are assumed to be uncorrelated, and each random error e is assumed to have zero mean and the same variance σ^2. The variance of e is the residual variability not explained by the model, in our case the sampling variability in the habitat.

In order to compute confidence intervals for means, perform significance tests, etc., we must make the further assumption that the errors are normally distributed.

Patchy distributions of organisms

If the observations are counts of organisms, the patchy distribution of most organisms leads to the violation of the assumed distribution of e. The counts generally have a skewed rather than a normal distribution, and large counts tend to have larger variances than small. The same is true for weights.

A probability model often proposed for count data is the Poisson model. A square root transformation of Poisson data results in transformed data with a constant variance of 0.25 and a more nearly normal distribution. Multiple regression and analysis of variance can therefore be applied to the transformed data.

When Y in equation (A.1.1) is a Poisson random variable, $E(Y) = \sigma^2$. If we have n observations y_i of Y, we can compute

$$\bar{y} = \frac{1}{n} \sum_{j=1}^{n} y_j \qquad \text{(A.1.2)}$$

which estimates $E(Y) = \sigma^2$ and the other standard estimate

$$s^2 = \frac{1}{n-1} \sum_{j=1}^{n} (y_j - \bar{y})^2 \qquad \text{(A.1.3)}$$

of σ^2. Then (Dixon and Massey 1969, p. 249)

$$\chi^2 = (n-1)\, s^2 / \bar{y} \qquad \text{(A.1.4)}$$

has an approximate χ^2 distribution with n-1 degrees of freedom.

A test for whether particular counts have a Poisson distribution is provided by the χ^2 statistic of (A.1.4). If the value of χ^2 computed from data $y_1, \ldots, y_n$ is too large, the Poisson model is inappropriate for these data. This test was performed for a number of rocky intertidal animal species. The Poisson model was rejected overwhelmingly in most cases. Values of $\chi^2/(n-1)$, which should be near one, were often in the tens or hundreds.

Although other probability models for patchiness exist, as pointed out by van Belle and Fisher (1977), there is little agreement on appropriate statistical procedures when the Poisson model is found to be inappropriate. For this reason we have not attempted to model counts and weights for any but the least patchy species in a given habitat.

Coefficient of variation

Even the least patchy species do not have normal distributions with equal variances. A simple statistic which reflects this fact is the coefficient of variation

$$CV = 100\, s / \bar{y} \qquad \text{(A.1.5)}$$

where $\bar{y}$ and s are defined by (A.1.2) and (A.1.3) respectively. The coefficient of variation expresses the standard deviation as a percentage of the mean of the counts or weights under consideration.

If the coefficient of variation is small, the species has an even distribution over the samples included in the computation; patchiness and variability are low.

Log transformation

If, as is more often the case, the CV is large but relatively constant when computed from different groups of samples, the implication is that the standard deviation of the counts or weights is proportional to the mean. In this case (see Dixon and Massey 1969, p. 324) it is likely that a logarithmic transformation of the data will produce transformed values which are more nearly normal in distribution and have more nearly equal variances.

Examination of counts and weights for a number of rocky intertidal species indicated that the CV was relatively constant. Both s and CV were computed separately for each date and elevation stratum sampled at Tongue Point. Four replicates were available in each group so we had $n = 4$ in (A.1.2) and (A.1.3). The results obtained from upper intertidal samples of *Chthamalus dalli* are typical. While s ranges from 3 to 1401 in the eight groups of samples, the range of CV is only 69 to 141.

We therefore used $\log_{10}$(count + 1) and $\log_{10}$(weight + 1) as the data for regression and analysis of variance in place of the untransformed counts or weights of an organism. We added one because $\log_{10}$ of zero does not exist, and zero counts and weights do occur in some replicates even for the most important species. Mean values and confidence intervals in log units can be transformed back to counts or weights. For example, if m is a mean of log transformed counts, the corresponding count value is 10^m-1. To express a confidence interval in the original units, both the upper and lower limits of the interval (l,u) must be transformed back, giving the interval $(10^l-1, 10^u-1)$ in the original units.

Normality of assemblage parameters

Even if the log transformation stabilizes the variances of population parameters, their normality may be open to question. The numerical assemblage parameters defined in Section 5 are more promising in this respect. While counts of each individual species may have distributions which are far from normal, central-limit theorems of statistics suggest that sums of such counts may have distributions which are more nearly normal. The assemblage parameter N_a is such a sum.

Similarly, S_a, S_p, W_a, W_p, H'_a, H'_b, H'_p, and percent plant cover can be viewed as sums of random variables. Hence a central-limit theorem can be invoked to claim that they should approach normality and that regression and analysis of variance are therefore appropriate.

Variance heterogeneity in assemblage parameters

The problem of heterogeneous error variances remains, particularly for N_a, W_a, W_p, and percent plant cover. The log transformation used for population counts and weights also proved necessary for N_a, W_a, and W_p. An appropriate variance-stabilizing transformation was not found for percent plant cover; an arcsine transformation was tried without success.

Another approach to eliminating variance heterogeneity is the selection of appropriate data subsets to use in analyses. For example, because values of numerical assemblage parameters vary strongly with elevation in the rocky intertidal, separate analyses of variance were done for the three elevation strata.

Confidence intervals

The confidence intervals (CI) given in this report are based on the normal parametric model. They have the form

$$(\bar{y} - t^*_{n-1} s\, n^{-1/2},\ \ \bar{y} + t^*_{n-1} s\, n^{-1/2}) \qquad \text{(A.1.6)}$$

for $\bar{y}$ and s given by (A.1.2) and (A.1.3). The percentile t^*_{n-1} of the *t*-distribution with n-1 degrees of freedom is obtained from a *t*-table (for example, p. 283 of the CRC Handbook, Beyer 1968). The 0.975 percentage point is chosen to obtain a 95% CI.

If we compute many 95% CI and if the normal model is appropriate, then in the long run 95 percent of these intervals will include the true mean value E(Y) of (A.1.1) which we are trying to estimate.

Confidence intervals for group means under the one-way analysis of variance model (A.3.1) have the form

$$(\bar{y}_i - t^*_{N-k}(MSE/n_i)^{-1/2},\ \ \bar{y}_i + t^*_{N-k}(MSE/n_i)^{-1/2}) \qquad \text{(A.1.7)}$$

where $\bar{y}_i$, N, k, MSE, and n_i are as in Table A-2 of Section A.3.

A.2 MULTIPLE REGRESSION

Model

The general multiple regression model is

$$y_j = B_0 + B_1 x_{1j} + \cdots + B_k x_{kj} + e_j \qquad \text{(A.2.1)}$$

where y_j is the jth observation of the dependent variable being modelled. In this study, y_j was a value of a numerical assemblage parameter, for example, S_p or $\log_{10}(N_a^j+1)$. The independent variables x_{1j}, ..., x_{kj} are the corresponding values of factors expected to influence y_j. The constants B_0, ..., B_k are the model parameters to be estimated.

The errors e_j are assumed to be uncorrelated with zero means and equal variances σ^2. If we wish to perform significance tests or compute confidence intervals for predicted y's or for the estimates b_0, ..., b_k of B_0, ..., B_k obtained in a regression analysis, we also need to assume that the errors are normally distributed.

The independent variables x_{ij} used in the present study represented effects of sample elevation, season, and long-term time trends. The specific variables considered in most of the analyses were:

x_{1j} = tidal elevation (meters)
$x_{2j} = x_{1j}^2$

x_{3j} = 1 for spring and summer (April - September)
= 0 for fall and winter (October - March)
x_{4j} = date of sample = year + (month - 1 + day/31) / 12

The squared elevation x_{2j} allows fitting a curve instead of a straight line to the dependent variable. For example, we can fit S_a at a site where its maximum is at a middle elevation and it decreases at both lower and higher elevations.

The multiple regression model can be used for prediction as follows:

1) Compute $b_0, \ldots, b_k$
2) Record $x_{1j}, \ldots, x_{kj}$ at a new time and place for which a prediction is desired
3) Predict the corresponding y_j by

$$Y_j = b_0 + b_1 x_{1j} + \cdots + b_k x_{kj} \qquad \text{(A.2.2)}$$

Weaknesses of predictive model

There are several weaknesses in this approach to prediction in the present study.

First, as noted in Section 4, the existing data base is deficient in such data as sediment size, beach slope, and exposure to waves and currents which might help to characterize site differences, so (A.2.2) could not be used for cross-site prediction.

Second, the estimated coefficients are only valid within the ranges of the independent variables from which they were computed. While we do not need to predict y_j for tidal elevations outside the ranges in the data base, our goal is to predict at future times. Significant long-term time trends detected in some parameters at some sites, for example increases in number of taxa identified, cannot be expected to continue into the future.

Third, there is evidence, discussed in Section 6, that the assumption of equal variances of the errors e_j is violated for some parameters.

Use of the model for assessing contributions to variability

The best use of the multiple regression model in the present context is for assessing the relative importance of the included variables as sources of variability. The analysis of variance Table A-1 is produced by a regression analysis. In this table "DF" stands for "degrees of freedom", "SS" stands for "sum of squares", and "MS" stands for "mean square". The summations are over the n observations y_j of (A.2.1) included in the analysis, $\bar{y}$ is defined by (A.1.2), and Y_j is defined by (A.2.2). The residual mean square MSE (sometimes called MS about regression or error MS) estimates the variance σ^2 of the errors e_j.

TABLE A-1. ANALYSIS OF VARIANCE TABLE FOR MULTIPLE REGRESSION

DUE TO	DF	SS	MS = SS/DF
Regression	k	$\sum_{j=1}^{n} (Y_j-\bar{y})^2$	
Residual	n-k-1	$\sum_{j=1}^{n} (y_j-Y_j)^2$	MSE
Total	n-1	$\sum_{j=1}^{n} (y_j-\bar{y})^2$	

From the analysis of variance table we can compute the statistic

$$R^2 = 100\ SS(\text{due to regression})/SS(\text{total}), \qquad (A.2.3)$$

the percentage of total variability in the data explained by the multiple regression model. R^2 can be tested to determine whether the percentage is significant. It can also be partitioned into the percentage due to each of the independent variables.

The estimated coefficients $b_1, \ldots, b_k$ give some indication of the magnitude and direction of the effects of the independent variables. For example, if b_1 is positive, y_j increases with x_{1j} while if b_1 is negative, increases in x_{1j} lead to decreases in y_j. Each estimated coefficient can be tested to determine whether it is significantly different from zero. The estimated standard deviations of the coefficients provide a less formal indication of their significance which does not require the assumption that the errors e_j are normally distributed.

Program used

Our multiple regression analyses were carried out using the Minitab program of Ryan, Joiner, and Ryan (1976).

A.3 ANALYSIS OF VARIANCE

As noted in Section 5, analysis of variance is a more natural model than multiple regression when the factors under consideration allow the data to be separated into a relatively small number of groups to be compared.

One-way analysis of variance

The simplest analysis of variance model, one-way analysis of variance, assumes that you have k groups (sometimes called "treatments" or "levels of a factor".) You have n_i observations y_{ij} in the ith group. The model assumes that

$$y_{ij} = \mu + \alpha_i + e_{ij} \tag{A.3.1}$$

where μ is an overall mean, α_i is the ith group effect, and the random errors e_{ij} are independent and identically distributed with mean zero and variance σ^2. The analysis of variance table summarizing the results of a one-way analysis of variance is shown in Table A-2.

TABLE A-2. ONE-WAY ANALYSIS OF VARIANCE TABLE

DUE TO	DF	SS	MS = SS/DF
Factor	k-1	$\sum_{i=1}^{k} n_i(\bar{y}_i-\bar{y})^2$	
Error	N-k	$\sum_{i=1}^{k} \sum_{j=1}^{n_i} (y_{ij}-\bar{y}_i)^2$	MSE
Total	N-1	$\sum_{i=1}^{k} \sum_{j=1}^{n_i} (y_{ij}-\bar{y})^2$	

In this table

$$N = \sum_{i=1}^{k} n_i, \tag{A.3.2}$$

$$\bar{y}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} y_{ij} \tag{A.3.3}$$

is a group mean which estimates $\mu + \alpha_i$, and

$$\bar{y} = \frac{1}{N} \sum_{i=1}^{k} \sum_{j=1}^{n_i} y_{ij} \tag{A.3.4}$$

estimates μ. MSE estimates the error variance σ^2, the within-group sampling variability not explained by the model. The square root of MSE is a pooled standard deviation which estimates σ and can therefore be used for calculating confidence intervals for group means, see (A.1.7).

We can use the statistic

$$F = (\text{Factor MS})/\text{MSE} \qquad \text{(A.3.5)}$$

to test whether there are any significant differences among the group means. However, we are usually seeking more specific information about between-group differences. Such information can be obtained by looking at contrasts (comparisons) among the means.

Orthogonal contrasts

Sets of orthogonal contrasts are particularly illuminating for comparing group means because they partition the between-group variability, represented by the Factor SS, into fractions due to the comparisons of interest.

A linear contrast

$$L_p = \sum_{i=1}^{k} c_{pi}\bar{y}_i \qquad \text{(A.3.6)}$$

with $c_{p1} + \ldots + c_{pk} = 0$ is orthogonal to another such contrast L_q if

$$\sum_{i=1}^{k} c_{pi}c_{qi}/n_i = 0. \qquad \text{(A.3.7)}$$

For any one-way analysis of variance, there are one or more ways to define a set of k-1 such contrasts for which

$$\sum_{p=1}^{k-1} \text{SS(due to } L_p) = \text{Factor SS} \qquad \text{(A.3.8)}$$

where

$$\text{SS(due to } L_p) = L_p^2/(\sum_{i=1}^{k} c_{pi}^2/n_i) \qquad \text{(A.3.9)}$$

is a sum of squares with one degree of freedom. The constants c_{pi} are chosen to define contrasts representing factors of interest.

For example, to compare the first group with the second we could set $c_{p1} = 1$, $c_{p2} = -1$, and $c_{p3} = \ldots = c_{pk} = 0$. If the resulting SS(due to L_p) is a large fraction of the Factor SS, we can conclude that much of the between-group variability is due to the difference between groups one and two.

Whether or not a particular fraction of the Factor SS represents a significant contrast depends on the level of significance of the Factor SS. The significance of each contrast can be assessed using the F statistic SS(due to L_p)/MSE. If the contrast is not significant, this statistic has an F distribution with 1 and N-k degrees of freedom.

Confounding

Since there are usually a number of ways to construct a set of orthogonal contrasts for a one-way analysis of variance, some subjectivity is involved in deciding which comparisons to perform. In addition, particularly in the data base of the present study, care must be used in interpreting particular comparisons because of the possibility of confounding of effects.

For example, when we wish to contrast Whidbey Island sites with similar sites from the Strait of Juan de Fuca, we average the means from the Whidbey sites and subtract the average of the Strait means to form L_p. However, any "Webber vs. Nyblade" differences will be caught in the contrast as well as "Whidbey vs. Strait" differences since all the Whidbey data were collected by Webber and all the Strait data by Nyblade.

Similarly, if we average data from several sand sites to contrast with gravel sites, differences in other factors such as exposure and salinity among the sites will affect our "sand vs. gravel" contrast. We have tried to point out such possible confounding in our discussions of analysis of variance results in Section 6.

Newman-Keuls procedure for comparing all means

The method of orthogonal contrasts has the disadvantage that in order to assess significance of a contrast we must do an individual F test. We performed many different one-way analyses of variance with a set of orthogonal contrasts for most of them. Hence, the overall probability of Type I error is much higher than the level of each individual test. We explain this problem and one approach we used to alleviate it in more detail in Section A.4.

Another approach to the problem is to use a multiple comparison procedure such as the Newman-Keuls procedure for comparing all group means. This procedure is described in detail in standard references for analysis of variance such as Winer (1971), pp. 191-201. Since we did not use it extensively in our analyses, we will not discuss it further in this appendix.

Random effects model

Some factors, for example season, which we use in defining groups for an analysis of variance are "fixed" factors. There are only four seasons, defining only four possible levels of the season factor.

Other factors have an infinite number of possible levels from which we have randomly chosen a small finite number to consider. Site can be viewed as such a factor. The mathematical model for such "random" factors is that the group effects α_i in (A.3.1), like the errors, are normally distributed with zero means and equal variances. The variance σ_α^2 of the α_i, called the between-group variance in the random effects model, can be estimated. It is a component of the variance of an observation; $\mathrm{var}(y_{ij}) = \sigma^2 + \sigma_\alpha^2$ under the random effects model.

In some of the analyses described in Section 6 we have estimated variance components and tested them for significance. The F statistic (A.3.5) is used for this test in the one-way random effects analysis of variance model as well as for testing for differences in means in the fixed effects model.

Variance heterogeneity

As noted in Section A.1, equal within-group variances and normality of errors are fundamental analysis of variance assumptions. While small departures from these assumptions generally will not seriously compromise results of the analysis, large departures are a matter of concern. Selection of relatively homogeneous subsets for analysis and log transformations of counts and weights were used to avoid serious violations of these assumptions.

In addition, we generally performed tests for equality of variances. Cochran's test (Winer 1971, p. 208) was used in some cases, but we more often chose the simpler Hartley maximum F ratio test (Winer 1971, pp.206-208). The maximum F ratio test statistic is

$$F_{max} = s_{max}^2 / s_{min}^2 \qquad \text{(A.3.10)}$$

where s_{max}^2 and s_{min}^2 are the maximum and minimum, respectively, of the k group variances

$$s_i^2 = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} (y_{ij} - \bar{y}_i)^2 \qquad \text{(A.3.11)}$$

where $\bar{y}_i$ is given by (A.3.3). Critical values for F_{max} are tabled in Winer (1971), p. 875, or the CRC Handbook (Beyer 1968), p. 329. We have reported variance heterogeneities detected by these tests in Section 6.

Two-way analysis of variance

In the one-way analysis of variance model we use contrasts to assess effects of more than one factor. An alternative approach to examining two factors which we have employed in some cases is two-way analysis of variance.

The two-way analysis of variance model assumes we have observations y_{ijk} satisfying

$$y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk} \qquad (A.3.12)$$

where μ and e_{ijk} are the overall mean and random error respectively, α_i and β_j are effects of the two factors, and $\alpha\beta_{ij}$ is a term representing the interaction of the two factors.

We have used a mixed model with the factor represented by α_i the random site factor and that represented by β_j a fixed factor (season or elevation). Expected mean squares under this model (Winer 1971, pp. 321-329) determine formulas for estimating the variance components σ^2 and σ_α^2 as well as the significance of fixed factor effects. Under this model,

$$\mathrm{var}(y_{ijk}) = \sigma^2 + \sigma_\alpha^2.$$

Nested analysis of variance

The final analysis of variance model we have used is a nested model which allows comparing the variance component due to sampling date within season and the error variance σ^2. This model, used for numerical assemblage parameters at a fixed site and stratum of elevation, is

$$y_{ijk} = \mu + \alpha_i + \beta_{j(i)} + e_{ijk} \qquad (A.3.13)$$

where y_{ijk} is an individual observation at the jth date within the ith season, e_{ijk} is the corresponding random error, μ is the overall mean at the site and elevation, α_i the ith season effect, and $\beta_{j(i)}$ the random effect due to date within season. If there are s seasons, t dates (times) within each season, and n observations at each time and season, then the analysis of variance table and formulas for variance components and F statistics are defined by Table A-3.

TABLE A-3. EXPECTED MEAN SQUARES FOR NESTED ANALYSIS OF VARIANCE

DUE TO	DF	EXPECTED MS
Season	s-1	$\sigma^2 + n\sigma_t^2 + \frac{nt}{s-1}\sum_{i=1}^{s}\alpha_i^2$
Time within season	s(t-1)	$\sigma^2 + n\sigma_t^2$
Error	st(n-1)	σ^2
Total	stn-1	

The time within season variance component is denoted by σ_t^2 in Table A-3. The variance of an observation at a given site and elevation is $var(y_{ijk}) = \sigma^2 + \sigma_t^2$ under this model. We estimate σ_t^2 by

$$\sigma_t^2 = [MS(\text{time within season}) - MSE]/n \qquad (A.3.14)$$

if this expression is positive, $\sigma_t^2 = 0$ otherwise. As always, the error mean square MSE estimates σ^2.

Programs used

One-way and two-way analyses of variance were carried out using Minitab (Ryan, Joiner, and Ryan 1976). Computations of contrasts and nested analyses of variance were performed using programs written by Zeh.

A.4 TESTING FOR SIGNIFICANT DIFFERENCES

In this section we review both general concepts of hypothesis testing and specific tests performed to obtain the results described in Section 6.

Type I and Type II errors, level, power

In the general statistical hypothesis testing situation, we have a "null hypothesis" H_o of no differences among statistical parameters being tested. A test of the null hypothesis may correctly accept or reject it. On the other hand, the test results may be in error.

Two types of errors are possible. A Type I error occurs when H_o is in fact true but the test incorrectly rejects it. A Type II error occurs when H_o is false but the test fails to reject it.

The "level of significance" of a test, often denoted by the symbol α, is the upper bound of the probability of making a Type I error. The level of a test is chosen prior to performing the test and determines the "critical value" of the test statistic which tells us to reject H_o. If we choose a very small value for the level and then find that the hypothesis should be rejected, we say the indicated difference is "highly significant." This is because the very small value of α represents the very low probability that we have made an error in rejecting H_o. The level of a test can be expressed either as a fraction (for example, $\alpha = 0.05$) or as a percent (the 5% level).

The "power" of a test is the probability that we correctly reject H_o when it is in fact false. In other words, power is 1 - probability of Type II error. It can also be expressed, as we have done in Section 6, as the percent probability of detecting a difference.

The power of a test depends on the magnitude of the true difference. For example, if we are testing for a difference in mean values $\mu + \alpha_i$ of two groups in a one-way analysis of variance, see (A.3.1), the power of the test is low if both groups have effects α_i near zero and hence means near μ. The power is higher if, say, α_i for the first group is zero but α_i for the second group is large so that the difference is the large α_i instead of being near zero.

Choice of α for tests on orthogonal contrasts

If we perform a statistical analysis which involves a single hypothesis test and we use a stated level α for that test, then the probability that we falsely reject H_o does not exceed α. If, on the other hand, we perform many such tests in the course of the analysis, then the probability of making a Type I error in at least one of the tests is much larger than α.

For example, if we do five independent tests at the $\alpha = 0.01$ level, then the probability of incorrectly proclaiming at least one significant difference is $1 - 0.99^5 = 0.05$, or 5% (Winer 1971, p. 175.) If we do twenty such tests, the probability of at least one such error jumps to over 18%.

Because we performed many different analyses of variance with sets of orthogonal contrasts for most of them, the probability of Type I error in asserting significance of contrasts would have been unacceptably high if we had used the conventional levels, $\alpha = 0.05$ or $\alpha = 0.01$. On the other hand, we generally did not wish to consider large numbers of a posteriori comparisons suggested by the data, so procedures allowing all possible comparisons seemed unnecessarily complicated and conservative. The compromise we adopted, namely testing contrasts for significance at the $\alpha = 0.001$ level, was suggested by the discussion of Winer (1971), pp. 172-201.

If we do 10 independent tests with $\alpha = 0.001$, the probability of at least one Type I error is 0.01 or less. We can do more than 50 such tests without increasing the probability of at least one such error to 0.05 or more. Hence it is unlikely that many of the significant contrasts indicated in the tables of Section 6 are due to Type I errors.

Two-sample t-tests, power to detect change

If an analysis of variance model such as (A.3.1), (A.3.12), or (A.3.13) is chosen for a population or assemblage parameter, then the appropriate group mean is used to predict that parameter at a future time. A two-sample *t*-test is generally employed if new replicate samples are collected and we wish to determine whether a change in the parameter has occurred. If the old group mean of the parameter is μ_1 and the new mean μ_2, then the null hypothesis being tested is $H_o: \mu_1 = \mu_2$.

If we have n_1 samples y_{1j} in the old group and n_2 new samples y_{2j} then the test statistic for the two-sample *t*-test is

$$t = \frac{|\bar{y}_1 - \bar{y}_2|}{s_p} (1/n_1 + 1/n_2)^{-1/2} \qquad \text{(A.4.1)}$$

where $\bar{y}_1$ and $\bar{y}_2$ are defined by (A.3.3) and

$$s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2} \qquad (A.4.2)$$

is a pooled variance estimate with s_1^2 and s_2^2 defined by (A.3.11). The critical value for the test is obtained from the *t*-distribution with n_1+n_2-2 degrees of freedom. The POOLED T command of Minitab performs this test.

Now assume that

$$\mu_2 = \mu_1 + \Delta\mu_1/100 \qquad (A.4.3)$$

so that Δ is the percent change in the mean. Then Table A-12b of Dixon and Massey (1969) gives values of

$$d = \frac{\Delta\mu_1}{100\,\sigma}(1/n_1 + 1/n_2)^{-1/2} \qquad (A.4.4)$$

which can be detected at specified levels α with specified powers. The standard deviation σ in (A.4.4) is the square root of the assumed common error variance of the old and new samples; s_p^2 of (A.4.2) is an estimate of this error variance.

To obtain percent changes in mean values detectable with specified probabilities by a two-sample *t*-test of specified level, we computed

$$\Delta = \frac{100\,\sigma\,d}{\mu_1}(1/n_1 + 1/n_2)^{1/2} \qquad (A.4.5)$$

for various values of d, n_1, and n_2 at the levels and powers tabled by Dixon and Massey. For μ_1 we used an appropriate group mean and for σ the pooled standard deviation from analysis of variance. For $n_1 = n_2$ we sometimes used Table IV.4 of the CRC Handbook (Beyer 1968) instead of the Dixon and Massey table. Values of $(\Delta\mu_1)/(100\,\sigma)$ instead of d are given in the CRC table, so $(1/n_1 + 1/n_2)^{1/2}$ need not be computed to get Δ.

If we are interested only in detecting a decrease in a population or assemblage parameter, we use $\bar{y}_1 - \bar{y}_2$ in place of $|\bar{y}_1 - \bar{y}_2|$ in (A.4.1) and the critical value for a one-sided instead of a two-sided test. The alternative to H_o assumed by the one-sided test is $H_a: \mu_1 > \mu_2$ while for the two-sided test it is $H_a: \mu_1 \neq \mu_2$. Our tables of detectable percent changes give the values corresponding to the two-sided test, with the values for the one-sided test in parentheses.

Two-sample Mann-Whitney tests

The two-sample *t*-test assumes that both groups of replicates being compared are normally distributed with variance σ^2. Only their mean values may differ. We have discussed extensively the problems with the *t*-test assumptions in biological data sets.

The two-sample Mann-Whitney test is a nonparametric alternative to the *t*-test. The null hypothesis tested by the Mann-Whitney test is that the observations y_{1j} in the old group have the same continuous probability distribution as the y_{2j} of the new group. We must assume only that the observations in each group are independent and identically distributed.

The nonparametric null hypothesis of the Mann-Whitney test makes no mention of group means. If, in fact, our interest is in testing for differences in some measure of the center of the distributions such as the mean or median, then we must add the assumption that the two distributions have the same shape and equal variances. They need not be normal in any case.

Several equivalent test statistics for the Mann-Whitney test exist. The one calculated by Minitab's **MANN-WHITNEY** procedure and other details concerning the test are described by Ryan, Joiner, and Ryan (1976).

Power to detect changes is harder to calculate for the Mann-Whitney than for the *t*-test. According to Siegel (1956), p. 126, the power efficiency of the Mann-Whitney test approaches 95.5 percent of that of the *t*-test when *t*-test assumptions are satisfied and $n_1 + n_2$ gets large. The Mann-Whitney test may be more powerful than the *t*-test when the assumptions of the latter are not satisfied.

Since normality and homogeneity of variances of population and assemblage parameters computed from the present data base are sometimes in question, the Mann-Whitney test should probably be used in place of or in addition to the *t*-test in testing for change.

A.5 CLUSTER ANALYSIS METHODOLOGY

As noted in Section 5, the key idea of cluster analysis is the division of a group of entities into smaller subgroups on the basis of "similarity" with respect to a set of attributes. Entities in a given subgroup are more similar to others in the same subgroup than to those in a different subgroup.

Our cluster analyses were performed using a package of computer programs for benthic community analysis by Bloom. Bloom (1977) briefly outlines the clustering methodologies used in the programs. More details can be found in Cormack (1971) or Clifford and Stephenson (1975). In this section we will give only a summary of the methods applied to the analyses of this study.

For clustering, a "station" was generally defined by pooling all available samples at a given site, date, and stratum of elevation. We generally used the index which Bloom (1977) calls the Czekanowski quantitative similarity index computed from log transformed data. If we are clustering on S species, then the similarity between station i and station j defined by this index is

$$c_{ij} = 2 \sum_{k=1}^{S} \min(x_{ik}, x_{jk}) / \sum_{k=1}^{S} (x_{ik}+x_{jk}) \tag{A.5.1}$$

where x_{ik} = ln(1 + count of species k at station i) and x_{jk} is defined similarly. Plants were given a count of one.

For subtidal analyses we used the Czekanowski qualitative index which defines the similarity between station i and station j as

$$c_{ij} = 2a/(2a+b+c) \tag{A.5.2}$$

where a is the number of species found at both stations, b is the number at station i only, and c is the number at station j only.

Computing the similarity matrix which has c_{ij} in row i and column j is only the first step in the cluster analysis. The next step is the application of a hierarchical classification procedure to the matrix to produce the clusters. The technique we used was group average sorting. The formula for similarity between group k and a group (ij) formed by the fusion of groups i and j is

$$c_{k(ij)} = \frac{n_i}{n_i+n_j} c_{ki} + \frac{n_j}{n_i+n_j} c_{kj} \tag{A.5.3}$$

if group i has n_i and group j n_j elements. When $n_i = n_j = n_k = 1$, c_{ki} and c_{kj} are just the appropriate elements of the similarity matrix. The procedure forms larger and larger groups by choosing groups to combine which have the largest possible between-group similarity. The similarity structure is then shown graphically in the dendrogram.

APPENDIX B

HABITAT DICTIONARIES AND RULES FOR CREATING THEM

As noted in Section 5, the numerous taxonomic errors and inconsistencies in the data base made it necessary to create dictionaries which associate taxonomic codes found on the File 100 tapes with the taxa to be used in analyses. Three such dictionaries were created, representing intertidal rock substrates, intertidal soft substrates, and subtidal substrates. We did not create a dictionary for intertidal cobble substrates since we did not perform detailed analyses of the cobble data.

The following general rules were used for "lumping" taxa in all three dictionaries:

1. Truncate all subspecies to species level since few subspecies were identified in the data set.

2. If only one species was identified in a genus and some samples were identified only to genus level, truncate to genus level. Use the same approach at the higher taxonomic levels; for example, lump a single genus in a family to family level.

3. If the vast majority of organisms in a genus are identified only to genus level, lump all species in the genus.

4. If the level to which Webber identified an organism clearly differs from the level to which the same organism was identified by Nyblade, lump to the lowest common level of identification. Similarly, if the level of identification by either investigator shows clear changes with time over the course of the WDOE or MESA studies or between studies, truncate to the lowest common level.

5. Truncate species coded by Nyblade with 99's (see Section 4.3.4) to the lowest level to which the Nyblade and NODC codes correspond.

6. Lump a species to genus level if it is unimportant and dubious according to the above rules. For example, if there are two species in a genus but only one or two samples of one of the species and many identifications only to genus level, lump all samples to genus level.

Some exceptions to these rules were dictated by biological considerations.

One example is among gammarid amphipods. Because it was known that neither investigator attempted to identify amphipods to species consistently throughout the studies, all were lumped in the rocky intertidal dictionary. However, several important amphipod genera and species appeared to be consistently identified in soft substrate intertidal and subtidal samples, so these were left at the lower level in the corresponding dictionaries. Another example was *Leptasterias hexactis*. Although it was the only species identified among the asteriidae in the rocky intertidal, it was considered sufficiently important, identifiable, and unique in the family to be left at the species level.

The rocky intertidal dictionary is given in Table B-1, the soft substrate intertidal dictionary in Table B-2, and the subtidal dictionary in Table B-3. The taxonomic codes found on the data tapes are given on the left in each of these tables, and the taxa used in analyses on the right. "ER" indicates that the taxonomic code on the tape was in error, and the corresponding data could not be used in analyses.

TABLE B-1. TAXONOMIC DICTIONARY FOR INTERTIDAL ROCK SUBSTRATES

03	CYANOPHYTA	03	CYANOPHYTA	
07	BACILLARIOPHYTA	07	BACILLARIOPHYTA	
0701	BACILLARIOPHYCEAE	07	BACILLARIOPHYTA	
0703	BACILLARIOPHYCEAE PE	07	BACILLARIOPHYTA	
07030501	NAVICULA	07	BACILLARIOPHYTA	
08	CHLOROPHYTA	08	CHLOROPHYTA	
0801	CHLOROPHYCEAE	08	CHLOROPHYTA	
0805	CHLOROPHYCEAE ULOTRI	0805	CHLOROPHYCEAE ULOTRI	
08050102	ULOTHRIX	08050102	ULOTHRIX	
0805010201	ULOTHRIX FLACCA	08050102	ULOTHRIX	
08050201	MONOSTROMA	08050201	MONOSTROMA	|*
0805020105	MONOSTROMA FUSCUM	08050201	MONOSTROMA	|
080503	ULVACEAE	080503	ULVACEAE	
08050301	BLIDINGIA	08050301	BLIDINGIA	
0805030101	BLIDINGIA MINIMA	08050301	BLIDINGIA	
08050303	ENTEROMORPHA	08050303	ENTEROMORPHA	
0805030302	ENTEROMORPHA COMPRES	0805030302	ENTEROMORPHA COMPRES	
0805030306	ENTEROMORPHA LINZA	0805030306	ENTEROMORPHA LINZA	*
0805030312	ENTEROMORPHA CRUCIAT	0805030312	ENTEROMORPHA CRUCIAT	
0805030317	ENTEROMORPHA INTESTI	0805030317	ENTEROMORPHA INTESTI	
08050305	ULVA (CHLOROPHYCE	08050305	ULVA (CHLOROPHYCE	|*
0805030501	ULVA FENESTRATA	08050305	ULVA (CHLOROPHYCE	|
0805030502	ULVA RIGIDA	08050305	ULVA (CHLOROPHYCE	|
0805030503	ULVA LACTUCA	08050305	ULVA (CHLOROPHYCE	|
0805030506	ULVA EXPANSA	08050305	ULVA (CHLOROPHYCE	|
0805030599	NAME NOT FOUND	08050305	ULVA (CHLOROPHYCE	|
08070102	SPONGOMORPHA	08070102	SPONGOMORPHA	
0807010202	SPONGOMORPHA COALITA	0807010202	SPONGOMORPHA COALITA	
0807010207	SPONGOMORPHA SPINESC	0807010207	SPONGOMORPHA SPINESC	
08070103	UROSPORA	08070103	UROSPORA	
0808	CHLOROPHYCEAE CLADOP	0808	CHLOROPHYCEAE CLADOP	
080801	CLADOPHORACEAE	080801	CLADOPHORACEAE	
08080101	CHAETOMORPHA	08080101	CHAETOMORPHA	
08080102	CLADOPHORA	08080102	CLADOPHORA	
0808010203	CLADOPHORA GRACILIS	08080102	CLADOPHORA	
08080103	RHIZOCLONIUM	08080103	RHIZOCLONIUM	
0808010301	RHIZOCLONIUM IMPLEXU	0808010301	RHIZOCLONIUM IMPLEXU	
0808010302	RHIZOCLONIUM RIPARIU	0808010302	RHIZOCLONIUM RIPARIU	
0809010101	DERBESIA MARINA	0809010101	DERBESIA MARINA	
08090301	CODIUM	08090301	CODIUM	
10300	NAME NOT FOUND	03	CYANOPHYTA	
10500	NAME NOT FOUND	16090717	CALLIARTHRON	
15	PHAEOPHYTA	15	PHAEOPHYTA	
1501	PHAEOPHYCEAE	15	PHAEOPHYTA	
150201	ECTOCARPACEAE	150201	ECTOCARPACEAE	

(continued)

*Starred species or groups are important taxa which were used for cluster analysis and, in some cases, population parameter analyses.

TABLE B-1 (continued)

15020103	ECTOCARPUS	15020103	ECTOCARPUS	
1502010303	ECTOCARPUS PARVUS	1502010303	ECTOCARPUS PARVUS	
1502010305	ECTOCARPUS SIMULANS	1502010305	ECTOCARPUS SIMULANS	
15020104	GIFFORDIA	15020104	GIFFORDIA	
1502010404	GIFFORDIA OVATA	15020104	GIFFORDIA	
1502010499	NAME NOT FOUND	15020104	GIFFORDIA	
15020106	PYLAIELLA	15020106	PYLAIELLA	
1502010601	PYLAIELLA LITTORALIS	15020106	PYLAIELLA	
1502010999	NAME NOT FOUND	15020109	FELDMANNIA	
150202	RALFSIACEAE	150202	RALFSIACEAE	
15020203	RALFSIA	150202	RALFSIACEAE	
1502020303	RALFSIA PACIFICA	150202	RALFSIACEAE	
1502050301	LEATHESIA DIFFORMIS	1502050301	LEATHESIA DIFFORMIS	
1502061001	HAPLOGLOIA ANDERSONI	1502061001	HAPLOGLOIA ANDERSONI	
1502061101	SAUNDERSELLA SIMPLEX	1502061101	SAUNDERSELLA SIMPLEX	
1502061202	ANALIPUS JAPONICUS	1502061202	ANALIPUS JAPONICUS	
1503	PHAEOPHYCEAE DICTYOS	1503	PHAEOPHYCEAE DICTYOS	
1503010201	STICTYOSIPHON TORTIL	1503	PHAEOPHYCEAE DICTYOS	
15040102	SPHACELARIA	15040102	SPHACELARIA	
1504010201	SPHACELARIA RACEMOSA	1504010201	SPHACELARIA RACEMOSA	
1504010202	SPHACELARIA SUBFUSCA	1504010202	SPHACELARIA SUBFUSCA	
1508	PHAEOPHYCEAE LAMINAR	1508	PHAEOPHYCEAE LAMINAR	
150802	LAMINARIACEAE	150802	LAMINARIACEAE	
15080201	LAMINARIA	15080201	LAMINARIA	
1508020102	LAMINARIA GROENLANDI	1508020102	LAMINARIA GROENLANDI	
1508020104	LAMINARIA SACCHARINA	1508020104	LAMINARIA SACCHARINA	
1508020105	LAMINARIA SETCHELLII	1508020105	LAMINARIA SETCHELLII	
1508020402	AGARUM FIMBRIATUM	1508020402	AGARUM FIMBRIATUM	
1508020501	COSTARIA COSTATA	1508020501	COSTARIA COSTATA	
1508020601	CYMATHERE TRIPLICATA	1508020601	CYMATHERE TRIPLICATA	
1508020701	HEDOPHYLLUM SESSILE	1508020701	HEDOPHYLLUM SESSILE	*
1508020901	PLEUROPHYCUS GARDNER	1508020901	PLEUROPHYCUS GARDNER	
1508021101	PHAEOSTROPHION IRREG	1508021101	PHAEOSTROPHION IRREG	
15080401	ALARIA	15080401	ALARIA	|*
1508040103	ALARIA MARGINATA	1508040103	ALARIA MARGINATA	|
1508040108	ALARIA TENUIFOLIA	1508040108	ALARIA TENUIFOLIA	|
1508040301	EGREGIA MENZIESII	1508040301	EGREGIA MENZIESII	
150902	DESMARESTIACEAE	150902	DESMARESTIACEAE	
15090201	DESMARESTIA	15090201	DESMARESTIA	
1509020101	DESMARESTIA ACULEATA	1509020101	DESMARESTIA ACULEATA	
1509020102	DESMARESTIA LIGULATA	1509020102	DESMARESTIA LIGULATA	
1509020103	DESMARESTIA VIRIDIS	1509020103	DESMARESTIA VIRIDIS	
1509020104	DESMARESTIA INTERMED	1509020104	DESMARESTIA INTERMED	
15100102	FUCUS	15100102	FUCUS	|*
1510010202	FUCUS DISTICHUS	15100102	FUCUS	|
1512010101	COLPOMENIA BULLOSA	1512010101	COLPOMENIA BULLOSA	
1512010201	PETALONIA FASCIA	1512010201	PETALONIA FASCIA	
1512010301	SCYTOSIPHON LOMENTAR	1512010301	SCYTOSIPHON LOMENTAR	

(continued)

TABLE B-1 (continued)

16	RHODOPHYTA	16	RHODOPHYTA	
1601	RHODOPHYCEAE	16	RHODOPHYTA	
1604010199	NAME NOT FOUND	16040101	GONIOTRICHUM	
1605	RHODOPHYCEAE BANGIOP	1605	RHODOPHYCEAE BANGIOP	
16050103	ERYTHROTRICHIA	16050103	ERYTHROTRICHIA	
1605010304	ERYTHROTRICHIA PARKS	16050103	ERYTHROTRICHIA	
1605010399	NAME NOT FOUND	16050103	ERYTHROTRICHIA	
1605010501	SMITHORA NAIADUM	1605010501	SMITHORA NAIADUM	
1605020102	BANGIA FUSCOPURPUREA	1605020102	BANGIA FUSCOPURPUREA	
16050202	PORPHYRA	16050202	PORPHYRA	|*
1605020209	PORPHYRA PERFORATA	16050202	PORPHYRA	|
1605020211	PORPHYRA PSEUDOLANCE	16050202	PORPHYRA	|
1605020221	PORPHYRA SANJUANENSI	16050202	PORPHYRA	|
1605020225	PORPHYRA ABBOTTAE	16050202	PORPHYRA	|
1605020228	PORPHYRA SMITHII	16050202	PORPHYRA	|
1607	RHODOPHYCEAE FLORIDE	1607	RHODOPHYCEAE FLORIDE	
16070101	ACROCHAETIUM	16070101	ACROCHAETIUM	
1607010107	ACROCHAETIUM PACIFIC	16070101	ACROCHAETIUM	
16070103	KYLINIA	16070103	KYLINIA	
16070104	RHODOCHORTON	16070104	RHODOCHORTON	
1607010402	RHODOCHORTON PURPURE	16070104	RHODOCHORTON	
1607040102	NEMALION ELMINTHOIDE	1607040102	NEMALION ELMINTHOIDE	
160801	CRUORIACEAE	160801	CRUORIACEAE	
16080103	PETROCELIS	16080103	PETROCELIS	
1608010302	PETROCELIS MIDDENDOR	16080103	PETROCELIS	
1608020101	NEOAGARDHIELLA BAILE	1608020101	NEOAGARDHIELLA BAILE	
16080501	PLOCAMIUM (RHODOPH	16080501	PLOCAMIUM (RHODOPH	
1608050101	PLOCAMIUM TENUE	1608050101	PLOCAMIUM TENUE	
1608050102	PLOCAMIUM COCCINEUM	1608050102	PLOCAMIUM COCCINEUM	
1608050103	PLOCAMIUM PACIFICUM	1608050103	PLOCAMIUM PACIFICUM	
1608050104	PLOCAMIUM VIOLACIUM	1608050104	PLOCAMIUM VIOLACIUM	
16080701	GRACILARIA	16080701	GRACILARIA	
1608070102	GRACILARIA VERRUCOSA	16080701	GRACILARIA	
1608070199	NAME NOT FOUND	16080701	GRACILARIA	
1608070399	NAME NOT FOUND	16080703	GRACILARIOPHILA	
1608090101	AHNFELTIA PLICATA	1608090101	AHNFELTIA PLICATA	
1608090102	AHNFELTIA GIGARTINOI	1608090102	AHNFELTIA GIGARTINOI	
1608090402	GYMNOGONGRUS LEPTOPH	1608090402	GYMNOGONGRUS LEPTOPH	
1608090403	GYMNOGONGRUS LINEARI	1608090403	GYMNOGONGRUS LINEARI	
160810	GIGARTINACEAE	160810	GIGARTINACEAE	
1608100102	CHONDRUS OCELLATUS	1608100102	CHONDRUS OCELLATUS	
16081002	GIGARTINA	16081002	GIGARTINA	|*
1608100201	GIGARTINA EXASPERATA	1608100201	GIGARTINA EXASPERATA	|
1608100203	GIGARTINA PAPILLATA	1608100203	GIGARTINA PAPILLATA	|
1608100204	GIGARTINA AGARDHII	1608100204	GIGARTINA AGARDHII	|
16081003	IRIDAEA	16081003	IRIDAEA	|*
1608100301	IRIDAEA CORDATA	1608100301	IRIDAEA CORDATA	|
1608100302	IRIDAEA CORNUCOPIAE	1608100302	IRIDAEA CORNUCOPIAE	|

(continued)

TABLE B-1 (continued)

1608100304	IRIDAEA HETEROCARPA	1608100304	IRIDAEA HETEROCARPA	¦
1608100305	IRIDAEA LINEARE	1608100305	IRIDAEA LINEARE	¦
16081004	RHODOGLOSSUM	16081004	RHODOGLOSSUM	
1608100401	RHODOGLOSSUM AFFINE	1608100401	RHODOGLOSSUM AFFINE	
1608100402	RHODOGLOSSUM CALIFOR	1608100402	RHODOGLOSSUM CALIFOR	
160901	SQUAMARIACEAE	160901	SQUAMARIACEAE	
1609010301	PEYSSONELIA PACIFICA	160901	SQUAMARIACEAE	
1609020101	DILSEA CALIFORNICA	1609020101	DILSEA CALIFORNICA	
1609020201	PIKEA CALIFORNICA	1609020201	PIKEA CALIFORNICA	
1609020402	FARLOWIA MOLLIS	1609020402	FARLOWIA MOLLIS	
1609020601	CRYPTOSIPHONIA WOODI	1609020601	CRYPTOSIPHONIA WOODI	
1609050101	ENDOCLADIA MURICATA	1609050101	ENDOCLADIA MURICATA	*
1609050201	GLOIOPELTIS FURCATA	1609050201	GLOIOPELTIS FURCATA	
16090601	HILDENBRANDIA (ALG	16090601	HILDENBRANDIA (ALG	
1609060101	HILDENBRANDIA OCCIDE	1609060101	HILDENBRANDIA OCCIDE	
1609060102	HILDENBRANDIA PROTOT	1609060102	HILDENBRANDIA PROTOT	
1609060105	NAME NOT FOUND	16090601	HILDENBRANDIA (ALG	
160907	CORALLINACEAE	160907	CORALLINACEAE	
16090703	CORALLINA	16090703	CORALLINA	¦ *
1609070301	CORALLINA VANCOUVERI	16090703	CORALLINA	¦
16090706	LITHOPHYLLUM	16090706	LITHOPHYLLUM	
16090707	LITHOTHAMNION	16090707	LITHOTHAMNION	
1609070701	LITHOTHAMNION CALIFO	16090707	LITHOTHAMNION	
1609070801	MELOBESIA MEDIOCRIS	16090708	MELOBESIA	
1609070899	NAME NOT FOUND	16090708	MELOBESIA	
16090709	MESOPHYLLUM	16090709	MESOPHYLLUM	
1609070901	MESOPHYLLUM LAMELLAT	1609070901	MESOPHYLLUM LAMELLAT	
1609070902	MESOPHYLLUM CONCHATU	1609070902	MESOPHYLLUM CONCHATU	
1609071303	CLATHROMORPHUM PARCU	1609071303	CLATHROMORPHUM PARCU	
16090715	BOSSIELLA	16090715	BOSSIELLA	¦ *
1609071505	BOSSIELLA PLUMOSA	16090715	BOSSIELLA	¦
16090717	CALLIARTHRON	16090717	CALLIARTHRON	
1609071701	CALLIARTHRON TUBERCU	16090717	CALLIARTHRON	
16090901	CRYPTONEMIA	16090901	CRYPTONEMIA	
1609090101	CRYPTONEMIA OBOVATA	1609090101	CRYPTONEMIA OBOVATA	
1609090102	CRYPTONEMIA OVALIFOL	1609090102	CRYPTONEMIA OVALIFOL	
1609090199	NAME NOT FOUND	16090901	CRYPTONEMIA	
1609090201	GRATELOUPIA DORYPHOR	1609090201	GRATELOUPIA DORYPHOR	
16090904	PRIONITIS	16090904	PRIONITIS	
1609090401	PRIONITIS LANCEOLATA	16090904	PRIONITIS	
16090905	HALYMENIA	16090905	HALYMENIA	
1609090501	HALYMENIA COCCINEA	16090905	HALYMENIA	
1609099999	NAME NOT FOUND	160909	CRYPTONEMIACEAE	
16091002	CALLOPHYLLIS	16091002	CALLOPHYLLIS	
1609100202	CALLOPHYLLIS EDENTAT	1609100202	CALLOPHYLLIS EDENTAT	
1609100204	CALLOPHYLLIS HAENOPH	1609100204	CALLOPHYLLIS HAENOPH	
1609100208	CALLOPHYLLIS FIRMA	1609100208	CALLOPHYLLIS FIRMA	
16091007	ERYTHROPHYLLUM	16091007	ERYTHROPHYLLUM	

(continued)

TABLE B-1 (continued)

1609100701	ERYTHROPHYLLUM DELES	16091007	ERYTHROPHYLLUM	
16091101	CHOREOCOLAX	16091101	CHOREOCOLAX	
1609110101	CHOREOCOLAX POLYSIPH	16091101	CHOREOCOLAX	
1609110201	HARVEYELLA MIRABILIS	1609110201	HARVEYELLA MIRABILIS	
1609130102	CONSTANTINEA SIMPLEX	1609130102	CONSTANTINEA SIMPLEX	
1610010201	LOMENTARIA BAILEYANA	1610010201	LOMENTARIA BAILEYANA	
16100202	RHODYMENIA	16100202	RHODYMENIA	
1610020202	RHODYMENIA PACIFICA	1610020202	RHODYMENIA PACIFICA	
1610020203	RHODYMENIA PALMATA	1610020203	RHODYMENIA PALMATA	
1610020205	RHODYMENIA STIPITATA	1610020205	RHODYMENIA STIPITATA	
1610020206	RHODYMENIA CALIFORNI	1610020206	RHODYMENIA CALIFORNI	
1610020301	RHODYMENIOCOLAX BOTR	1610020301	RHODYMENIOCOLAX BOTR	
1610020501	HALOSACCION GLANDIFO	1610020501	HALOSACCION GLANDIFO	*
1610020602	FAUCHEA FRYEANA	1610020602	FAUCHEA FRYEANA	
1610020702	PALMARIA PALMATA	1610020702	PALMARIA PALMATA	
1610020901	LEPTOFAUCHEA PACIFIC	1610020901	LEPTOFAUCHEA PACIFIC	
161101	CERAMIACEAE HOM.1	161101	CERAMIACEAE HOM.1	
16110101	ANTITHAMNION	16110101	ANTITHAMNION	
1611010104	ANTITHAMNION DENDROI	1611010104	ANTITHAMNION DENDROI	
1611010106	ANTITHAMNION KYLINII	1611010106	ANTITHAMNION KYLINII	
1611010109	ANTITHAMNION DEFECTU	1611010109	ANTITHAMNION DEFECTU	
16110102	CALLITHAMNION	16110102	CALLITHAMNION	|*
1611010207	CALLITHAMNION PIKEAN	1611010207	CALLITHAMNION PIKEAN	|
1611010208	CALLITHAMNION ACUTUM	1611010208	CALLITHAMNION ACUTUM	|
16110103	BORNETIA	16110103	BORNETIA	
16110104	CERAMIUM	16110104	CERAMIUM	
1611010405	CERAMIUM STRICTUM	1611010405	CERAMIUM STRICTUM	
1611010408	CERAMIUM PACIFICUM	1611010408	CERAMIUM PACIFICUM	
1611010409	CERAMIUM CODICOLA	1611010409	CERAMIUM CODICOLA	
1611010410	CERAMIUM CALIFORNICU	1611010410	CERAMIUM CALIFORNICU	
1611010411	CERAMIUM GARDNERI	1611010411	CERAMIUM GARDNERI	
1611010413	CERAMIUM WASHINGTONI	1611010413	CERAMIUM WASHINGTONI	
1611010499	NAME NOT FOUND	16110104	CERAMIUM	
16110113	MICROCLADIA	16110113	MICROCLADIA	
1611011301	MICROCLADIA BOREALIS	1611011301	MICROCLADIA BOREALIS	*
1611011302	MICROCLADIA COULTERI	1611011302	MICROCLADIA COULTERI	
16110114	PLEONOSPORIUM	16110114	PLEONOSPORIUM	
1611011403	PLEONOSPORIUM VANCOU	16110114	PLEONOSPORIUM	
1611011499	NAME NOT FOUND	16110114	PLEONOSPORIUM	
1611011601	PTILOTA FILICINA	1611011601	PTILOTA FILICINA	
1611011602	PTILOTA PECTINATA	1611011602	PTILOTA PECTINATA	
16110122	ANTITHAMNIONELLA	16110122	ANTITHAMNIONELLA	
1611012201	ANTITHAMNIONELLA GLA	1611012201	ANTITHAMNIONELLA GLA	
1611012202	ANTITHAMNIONELLA PAC	1611012202	ANTITHAMNIONELLA PAC	
16110123	PLATYTHAMNION	16110123	PLATYTHAMNION	
1611012301	PLATYTHAMNION PECTIN	1611012301	PLATYTHAMNION PECTIN	
1611012302	PLATYTHAMNION VILLOS	1611012302	PLATYTHAMNION VILLOS	
1611012303	PLATYTHAMNION REVERS	1611012303	PLATYTHAMNION REVERS	

(continued)

TABLE B-1 (continued)

1611012304	PLATYTHAMNION HETERO	1611012304	PLATYTHAMNION HETERO	
1611012401	NEOPTILOTA ASPLENIOI	1611012401	NEOPTILOTA ASPLENIOI	
1611012402	NEOPTILOTA HYPNOIDES	1611012402	NEOPTILOTA HYPNOIDES	
1611012403	NEOPTILOTA CALIFORNI	1611012403	NEOPTILOTA CALIFORNI	
16110125	HOLLENBERGIA	16110125	HOLLENBERGIA	
16110126	SCAGELONEMA/SCAGELIA	16110126	SCAGELONEMA/SCAGELIA	
1611012601	SCAGELIA OCCIDENTALE	16110126	SCAGELONEMA/SCAGELIA	
1611012701	TIFFANIELLA SNYDERAE	1611012701	TIFFANIELLA SNYDERAE	
1611012801	PTILOTHAMNIONOPSIS L	1611012801	PTILOTHANIOPSIS	
1611012899	NAME NOT FOUND	1611012801	PTILOTHANIOPSIS	
161102	DELESSERIACEAE	161102	DELESSERIACEAE	
16110206	DELESSERIA	16110206	DELESSERIA	
1611020601	DELESSERIA DECIPIENS	16110206	DELESSERIA	
1611020901	GONIMOPHYLLUM SKOTTS	1611020901	GONIMOPHYLLUM SKOTTS	
16110211	MEMBRANOPTERA	16110211	MEMBRANOPTERA	
1611021102	MEMBRANOPTERA DIMORP	1611021102	MEMBRANOPTERA DIMORP	
1611021103	MEMBRANOPTERA PLATYP	1611021103	MEMBRANOPTERA PLATYP	
1611021108	MEMBRANOPTERA MULTIR	1611021108	MEMBRANOPTERA MULTIR	
16110214	PHYCODRYS	16110214	PHYCODRYS	
1611021404	PHYCODRYS SETCHELLII	16110214	PHYCODRYS	
1611021499	NAME NOT FOUND	16110214	PHYCODRYS	
1611021501	POLYNEURA LATISSIMA	1611021501	POLYNEURA LATISSIMA	
1611022003	NIENBURGIA ANDERSONI	1611022003	NIENBURGIA ANDERSONI	
16110224	HYMENENA	16110224	HYMENENA	
1611022402	HYMENENA FLABELLIGER	16110224	HYMENENA	
1611022499	NAME NOT FOUND	16110224	HYMENENA	
16110227	PLATYSIPHONIA	16110227	PLATYSIPHONIA	
16110302	HETEROSIPHONIA	16110302	HETEROSIPHONIA	
16110401	POLYSIPHONIA	16110401	POLYSIPHONIA	¦*
1611040101	POLYSIPHONIA HENDRYI	1611040101	POLYSIPHONIA HENDRYI	¦
1611040103	POLYSIPHONIA PACIFIC	1611040103	POLYSIPHONIA PACIFIC	¦
1611040104	POLYSIPHONIA URCEOLA	1611040104	POLYSIPHONIA URCEOLA	¦
1611040105	POLYSIPHONIA BRODIAE	1611040105	POLYSIPHONIA BRODIAE	¦
1611040115	POLYSIPHONIA TENUIST	1611040115	POLYSIPHONIA TENUIST	¦
16110402	PTEROSIPHONIA	16110402	PTEROSIPHONIA	
1611040202	PTEROSIPHONIA BIPINN	1611040202	PTEROSIPHONIA BIPINN	*
1611040203	PTEROSIPHONIA DENDRO	1611040203	PTEROSIPHONIA DENDRO	
1611040204	PTEROSIPHONIA GARDNE	1611040204	PTEROSIPHONIA GARDNE	
1611040401	LAURENCIA SPECTABILI	1611040401	LAURENCIA SPECTABILI	
1611040501	RHODOMELA LARIX	1611040501	RHODOMELA LARIX	*
1611040502	RHODOMELA LYCOPODIOI	1611040502	RHODOMELA LYCOPODIOI	
16110406	ODONTHALIA	16110406	ODONTHALIA	¦*
1611040603	ODONTHALIA FLOCCOSA	1611040603	ODONTHALIA FLOCCOSA	¦
1611040605	ODONTHALIA LYALLII	1611040605	ODONTHALIA LYALLII	¦
1611040606	ODONTHALIA WASHINGTO	1611040606	ODONTHALIA WASHINGTO	¦
1611040607	ODONTHALIA KAMTSCHAT	1611040607	ODONTHALIA KAMTSCHAT	¦
16110407	LOPHOSIPHONIA	16110407	LOPHOSIPHONIA	
16110412	HERPOSIPHONIA	16110412	HERPOSIPHONIA	

(continued)

TABLE B-1 (continued)

1611041202	HERPOSIPHONIA GRANDI	1611041202	HERPOSIPHONIA GRANDI
1611041203	HERPOSIPHONIA PLUMUL	1611041203	HERPOSIPHONIA PLUMUL
20200	NAME NOT FOUND	37600104	TEALIA
20230	NAME NOT FOUND	37310101	HALICLYSTUS
2062U	NAME NOT FOUND	51050105	NUCELLA
20630	NAME NOT FOUND	551507	ERYCINIDAE
20710	NAME NOT FOUND	5001	POLYCHAETA
20950	NAME NOT FOUND	6157010401	PANCOLUS CALIFORNIEN
20990	NAME NOT FOUND	6117	COPEPODA
21100	NAME NOT FOUND	65	INSECTA IV
21510	NAME NOT FOUND	8129030303	DIAMPHIODIA PERIERCT
21620	NAME NOT FOUND	8831020701	CLINOCOTTUS ACUTICEP
33260103	PHYLLOSPADIX	33260103	PHYLLOSPADIX
3326010301	PHYLLOSPADIX SCOULER	33260103	PHYLLOSPADIX
36	PORIFERA	36	PORIFERA
36630201	HALICLONA	36630201	HALICLONA
3663020102	HALICLONA PERMOLLIS	36630201	HALICLONA
36640708	OPHLITASPONGIA	36640708	OPHLITASPONGIA
3664070801	OPHLITASPONGIA PENNA	36640708	OPHLITASPONGIA
3665020202	HALICHONDRIA PANICEA	3665020202	HALICHONDRIA PANICEA
3702	HYDROZOA HYDROIDA	3702	HYDROZOA HYDROIDA
3704	HYDROZOA HYDROIDA LE	3704	HYDROZOA HYDROIDA LE
37040102	OBELIA	37040102	OBELIA
37040104	PHIALIDIUM	37040104	PHIALIDIUM
3704040	NAME NOT FOUND	370404	CAMPANULINIDAE
37040502	SERTULARELLA	37040502	SERTULARELLA
37040503	SERTULARIA	37040503	SERTULARIA
37040504	ABIETINARIA	37040504	ABIETINARIA
37310101	HALICLYSTUS	37310101	HALICLYSTUS
3740	ANTHOZOA	3740	ANTHOZOA
3760	ZOANTHARIA ACTINIARI	3760	ZOANTHARIA ACTINIARI
376001	ACTINIIDAE	376001	ACTINIIDAE
3760010201	ANTHOPLEURA ELEGANTI	3760010201	ANTHOPLEURA ELEGANTI
3760010301	EPIACTIS PROLIFERA	3760010301	EPIACTIS PROLIFERA
37600104	TEALIA	37600104	TEALIA
376001999	NAME NOT FOUND	376001	ACTINIIDAE
3760019999	NAME NOT FOUND	376001	ACTINIIDAE
39	PLATYHELMINTHES	39	PLATYHELMINTHES
3901	TURBELLARIA	39	PLATYHELMINTHES
43	RHYNCHOCOELA	43	RHYNCHOCOELA
4303020208	CEREBRATULUS CALIFOR	4303020208	CEREBRATULUS CALIFOR
4306010102	EMPLECTONEMA GRACILE	4306010102	EMPLECTONEMA GRACILE
4306010603	PARANEMERTES PEREGRI	4306010603	PARANEMERTES PEREGRI
43060501	AMPHIPORUS	43060501	AMPHIPORUS
4306050199	NAME NOT FOUND	43060501	AMPHIPORUS
47	NEMATODA	47	NEMATODA
5001	POLYCHAETA	5001	POLYCHAETA
500101	APHRODITIDAE	500101	APHRODITIDAE

(continued)

TABLE B-1 (continued)

500102	POLYNOIDAE	500102	POLYNOIDAE	
5001020701	HALOSYDNA BREVISETOS	5001020701	HALOSYDNA BREVISETOS	
50010208	HARMOTHOE	50010208	HARMOTHOE	
5001020806	HARMOTHOE IMBRICATA	5001020806	HARMOTHOE IMBRICATA	
5001020810	HARMOTHOE LUNULATA	5001020810	HARMOTHOE LUNULATA	
500106	SIGALIONIDAE	500106	SIGALIONIDAE	
5001060101	PHOLOE MINUTA	500106	SIGALIONIDAE	
500108	CHRYSOPETALIDAE	500108	CHRYSOPETALIDAE	
5001080101	PALEANOTUS BELLIS	500108	CHRYSOPETALIDAE	
500113	PHYLLODOCIDAE	500113	PHYLLODOCIDAE	
50011301	ANAITIDES/PHYLLODOCE	50011301	ANAITIDES/PHYLLODOCE	
5001130101	ANAITIDES CITRINA	5001130101	ANAITIDES CITRINA	
5001130106	ANAITIDES MACULATA	5001130106	ANAITIDES MACULATA	
50011302	ETEONE	50011302	ETEONE	
5001130205	ETEONE LONGA	50011302	ETEONE	
50011303	EULALIA	50011303	EULALIA	
5001130301	EULALIA VIRIDIS	5001130301	EULALIA VIRIDIS	
5001130302	EULALIA SANGUINEA	5001130302	EULALIA SANGUINEA	
5001130304	EULALIA BILINEATA	5001130304	EULALIA BILINEATA	
5001130306	EULALIA QUADRIOCULAT	5001130306	EULALIA QUADRIOCULAT	
5001130307	EULALIA NIGRIMACULAT	5001130307	EULALIA NIGRIMACULAT	
50011307	GENETYLLIS	50011307	GENETYLLIS	
5001130901	HESIONURA COINEAUI	5001130901	HESIONURA COINEAUI	
50011311	EUMIDA	50011311	EUMIDA	
500121	HESIONIDAE	500121	HESIONIDAE	
5001210401	OPHIODROMUS PUGETTEN	5001210401	OPHIODROMUS PUGETTEN	
5001210801	MICROPODARKE DUBIA	5001210801	MICROPODARKE DUBIA	
500123	SYLLIDAE	500123	SYLLIDAE	
50012301	AUTOLYTUS	50012301	AUTOLYTUS	
50012303	SYLLIS	50012303	SYLLIS	*
50012305	TYPOSYLLIS	50012305	TYPOSYLLIS	*
5001230501	TYPOSYLLIS ALTERNATA	5001230501	TYPOSYLLIS ALTERNATA	
5001230505	TYPOSYLLIS PULCHRA	5001230505	TYPOSYLLIS PULCHRA	
5001230506	TYPOSYLLIS STEWARTI	5001230506	TYPOSYLLIS STEWARTI	
5001230507	TYPOSYLLIS FASCIATA	5001230507	TYPOSYLLIS FASCIATA	
5001230509	TYPOSYLLIS ADAMANTEA	5001230509	TYPOSYLLIS ADAMANTEA	
5001230511	TYPOSYLLIS HYALINA	5001230511	TYPOSYLLIS HYALINA	
5001230512	TYPOSYLLIS VARIEGATA	5001230512	TYPOSYLLIS VARIEGATA	
5001230601	EUSYLLIS ASSIMILIS	5001230601	EUSYLLIS ASSIMILIS	
50012307	EXOGONE	50012307	EXOGONE	
5001230702	EXOGONE GEMMIFERA	5001230702	EXOGONE GEMMIFERA	
5001230703	EXOGONE LOUREI	5001230703	EXOGONE LOUREI	
5001230706	EXOGONE VERUGERA	5001230706	EXOGONE VERUGERA	
50012308	SPHAEROSYLLIS	50012308	SPHAEROSYLLIS	
5001230805	SPHAEROSYLLIS PERIFE	5001230805	SPHAEROSYLLIS PERIFE	
5001230806	SPHAEROSYLLIS BRANDH	5001230806	SPHAEROSYLLIS BRANDH	
5001230901	BRANIA BREVIPHARYNGE	5001230901	BRANIA BREVIPHARYNGE	
50012313	ODONTOSYLLIS	50012313	ODONTOSYLLIS	

(continued)

TABLE B-1 (continued)

500124	NEREIDAE	500124	NEREIDAE	
50012404	NEREIS	50012404	NEREIS	|*
5001240403	NEREIS PELAGICA	5001240403	NEREIS PELAGICA	|
5001240405	NEREIS VEXILLOSA	5001240405	NEREIS VEXILLOSA	|
5001240406	NEREIS ZONATA	5001240406	NEREIS ZONATA	|
5001240495	NAME NOT FOUND	50012404	NEREIS	|
5001240501	PLATYNEREIS BICANALI	5001240501	PLATYNEREIS BICANALI	*
50012501	NEPHTYS	50012501	NEPHTYS	
5001260201	SPHAERODOROPSIS MINU	5001260201	SPHAERODOROPSIS MINU	
5001280101	GLYCINDE PICTA	5001280101	GLYCINDE PICTA	
500129	ONUPHIDAE	500129	ONUPHIDAE	
50012901	ONUPHIS	500129	ONUPHIDAE	
5001290106	ONUPHIS STIGMATIS	500129	ONUPHIDAE	
500130	EUNICIDAE	500130	EUNICIDAE	
5001300102	EUNICE VALENS	500130	EUNICIDAE	
500131	LUMBRINERIDAE	500131	LUMBRINERIDAE	
50013101	LUMBRINEREIS	50013101	LUMBRINEREIS	|*
5001310106	LUMBRINEREIS ZONATA	5001310106	LUMBRINEREIS ZONATA	|
5001310108	LUMBRINEREIS INFLATA	5001310108	LUMBRINEREIS INFLATA	|
5001310111	LUMBRINEREIS PALLIDA	5001310111	LUMBRINEREIS PALLIDA	|
50013601	DORVILLEA/SCHISTOMER	50013601	DORVILLEA/SCHISTOMER	
500140	ORBINIIDAE	500140	ORBINIIDAE	
50014002	NAINERIS	50014002	NAINERIS	
5001400201	NAINERIS DENDRITICA	5001400201	NAINERIS DENDRITICA	
5001400202	NAINERIS QUADRICUSPI	5001400202	NAINERIS QUADRICUSPI	
50014003	SCOLOPLOS	50014003	SCOLOPLOS	
5001400301	SCOLOPLOS ARMIGER	5001400301	SCOLOPLOS ARMIGER	
5001400302	SCOLOPLOS PUGETTENSI	5001400302	SCOLOPLOS PUGETTENSI	
5001410501	PARAONELLA PLATYBRAN	5001410501	PARAONELLA PLATYBRAN	
500143	SPIONIDAE	500143	SPIONIDAE	
5001430201	LAONICE CIRRATA	5001430201	LAONICE CIRRATA	
50014303	NERINE	50014303	NERINE	
50014304	POLYDORA	50014304	POLYDORA	
5001430411	POLYDORA LIGNI	5001430411	POLYDORA LIGNI	
5001430412	POLYDORA WEBSTERI	5001430412	POLYDORA WEBSTERI	
5001430415	POLYDORA LIMICOLA	5001430415	POLYDORA LIMICOLA	
5001430417	POLYDORA PYGIDIALIS	5001430417	POLYDORA PYGIDIALIS	
50014305	PRIONOSPIO	50014305	PRIONOSPIO	
5001430502	PRIONOSPIO CIRRIFERA	50014305	PRIONOSPIO	
50014307	SPIO	50014307	SPIO	
5001430701	SPIO FILICORNIS	50014307	SPIO	
50014308	BOCCARDIA	50014308	BOCCARDIA	
5001430801	BOCCARDIA COLUMBIANA	5001430801	BOCCARDIA COLUMBIANA	
5001430806	BOCCARDIA HAMATA	5001430806	BOCCARDIA HAMATA	
5001431302	PYGOSPIO ELEGANS	5001431302	PYGOSPIO ELEGANS	
50014314	MALACOCEROS	50014314	MALACOCEROS	
5001431401	MALACOCEROS GLUTAEUS	50014314	MALACOCEROS	
500150	CIRRATULIDAE	500150	CIRRATULIDAE	

(continued)

TABLE B-1 (continued)

50015001	CIRRATULUS	50015001	CIRRATULUS
5001500101	CIRRATULUS CIRRATUS	50015001	CIRRATULUS
50015003	THARYX	50015003	THARYX
5001500302	THARYX MULTIFILIS	50015003	THARYX
50015005	DODECACERIA	50015005	DODECACERIA
5001500502	DODECACERIA FEWKESI	50015005	DODECACERIA
5001540302	PHERUSA PLUMOSA	5001540302	PHERUSA PLUMOSA
5001580202	ARMANDIA BREVIS	5001580202	ARMANDIA BREVIS
500160	CAPITELLIDAE	500160	CAPITELLIDAE
5001600101	CAPITELLA CAPITATA	5001600101	CAPITELLA CAPITATA
50016004	MEDIOMASTUS	50016004	MEDIOMASTUS
5001600401	MEDIOMASTUS AMBISETA	50016004	MEDIOMASTUS
500162	ARENICOLIDAE	500162	ARENICOLIDAE
50016201	ABARENICOLA	50016201	ABARENICOLA
5001620104	ABARENICOLA OCEANICA	50016201	ABARENICOLA
5001620301	BRANCHIOMALDANE VICE	5001620301	BRANCHIOMALDANE VICE
500163	MALDANIDAE	500163	MALDANIDAE
5001630802	AXIOTHELLA RUBROCINC	500163	MALDANIDAE
50016401	OWENIA	50016401	OWENIA
5001640102	OWENIA FUSIFORMIS	50016401	OWENIA
5001650102	IDANTHYRSUS ARMATUS	5001650102	IDANTHYRSUS ARMATUS
5001650201	SABELLARIA CEMENTARI	5001650201	SABELLARIA CEMENTARI
500167	AMPHARETIDAE	500167	AMPHARETIDAE
500168	TEREBELLIDAE	500168	TEREBELLIDAE
5001680101	AMPHITRITE CIRRATA	5001680101	AMPHITRITE CIRRATA
5001680201	EUPOLYMNIA HETEROBRA	5001680201	EUPOLYMNIA HETEROBRA
5001680601	NICOLEA ZOSTERICOLA	5001680601	NICOLEA ZOSTERICOLA
50016807	PISTA	50016807	PISTA
5001680702	PISTA FASCIATA	5001680702	PISTA FASCIATA
5001680703	PISTA ELONGATA	5001680703	PISTA ELONGATA
50016808	POLYCIRRUS	50016808	POLYCIRRUS
50016810	THELEPUS	50016810	THELEPUS
5001681001	THELEPUS CRISPUS	50016810	THELEPUS
50016825	STREBLOSOMA	50016825	STREBLOSOMA
500170	SABELLIDAE	500170	SABELLIDAE
50017001	CHONE	50017001	CHONE
5001700105	CHONE ECAUDATA	50017001	CHONE
50017003	EUDISTYLIA	50017003	EUDISTYLIA
5001700303	EUDISTYLIA VANCOUVER	50017003	EUDISTYLIA
50017006	POTAMILLA	50017006	POTAMILLA
5001700602	POTAMILLA MYRIOPS	50017006	POTAMILLA
5001700699	NAME NOT FOUND	50017006	POTAMILLA
50017007	PSEUDOPOTAMILLA	50017007	PSEUDOPOTAMILLA
5001700701	PSEUDOPOTAMILLA INTE	50017007	PSEUDOPOTAMILLA
5001700802	SABELLA MEDIA	5001700802	SABELLA MEDIA
5001700902	SCHIZOBRANCHIA INSIG	5001700902	SCHIZOBRANCHIA INSIG
50017013	FABRICIA	50017013	FABRICIA
5001701301	FABRICIA SABELLA	5001701301	FABRICIA SABELLA

(continued)

TABLE B-1 (continued)

5001701302	FABRICIA MINUTA	5001701302	FABRICIA MINUTA	
5001701502	MANAYUNKIA	50017015	MANAYUNKIA	
5001701599	NAME NOT FOUND	50017015	MANAYUNKIA	
50017020	ORIOPSIS	50017020	ORIOPSIS	
50017021	SABELLASTARTE	50017021	SABELLASTARTE	
500173	SERPULIDAE	500173	SERPULIDAE	
5001730401	SERPULA VERMICULARIS	5001730401	SERPULA VERMICULARIS	
50017305	SPIRORBIS	50017305	SPIRORBIS	
5001730510	SPIRORBIS NAKAMURAI	50017305	SPIRORBIS	
5001730599	NAME NOT FOUND	50017305	SPIRORBIS	
5001730602	DEXIOSPIRA SPIRILLUM	5001730602	DEXIOSPIRA SPIRILLUM	
500202	PROTODRILIDAE	500202	PROTODRILIDAE	
50020501	POLYGORDIUS	50020501	POLYGORDIUS	
5004	OLIGOCHAETA	5004	OLIGOCHAETA	
500501	LUMBRICULIDAE	500501	LUMBRICULIDAE	
500901	ENCHYTRAEIDAE	500901	ENCHYTRAEIDAE	
501	NAME NOT FOUND	6501	DIPTERA	
51	GASTROPODA	51	GASTROPODA	
5102040401	DIODORA ASPERA	5102040401	DIODORA ASPERA	
510205	ACMAEIDAE	510205	ACMAEIDAE	
51020501	TECTURA	51020501	TECTURA	
5102050103	ACMAEA MITRA	51020501	TECTURA	
51020502	COLLISELLA	51020502	COLLISELLA	
5102050201	COLLISELLA PELTA	5102050201	COLLISELLA PELTA	*
5102050202	COLLISELLA DIGITALIS	5102050202	COLLISELLA DIGITALIS	*
5102050203	COLLISELLA OCHRACEA	5102050203	COLLISELLA OCHRACEA	
5102050207	COLLISELLA STRIGATEL	5102050207	COLLISELLA STRIGATEL	*
5102050301	NOTOACMAEA SCUTUM	5102050301	NOTOACMAEA SCUTUM	*
5102050302	NOTOACMAEA PERSONA	5102050302	NOTOACMAEA PERSONA	
5102050303	NOTOACMAEA FENESTRAT	5102050303	NOTOACMAEA FENESTRAT	
5102050305	NAME NOT FOUND	5102050305	NOTOACMAEA SP.	
5102100103	CALLIOSTOMA LIGATUM	5102100103	CALLIOSTOMA LIGATUM	
51021003	MARGARITES/LIRULARIA	51021003	MARGARITES/LIRULARIA	
5102100308	MARGARITES PUPILLUS	5102100308	MARGARITES PUPILLUS	
5102100310	MARGARITES LIRULATUS	5102100310	MARGARITES LIRULATUS	
5102100312	MARGARITES SUCCINCTU	5102100312	MARGARITES SUCCINCTU	
5102100599	NAME NOT FOUND	51021005	TEGULA	
51021201	HOMALOPOMA	51021201	HOMALOPOMA	
5102120102	HOMALOPOMA LURIDUM	5102120102	HOMALOPOMA LURIDUM	
5102120103	HOMALOPOMA BACULUM	5102120103	HOMALOPOMA BACULUM	
5102120199	NAME NOT FOUND	51021201	HOMALOPOMA	
51021202	MOELLERIA	51021202	MOELLERIA	
510214	PHASIANELLIDAE	510214	PHASIANELLIDAE	
51030903	LACUNA	51030903	LACUNA	|*
5103090302	LACUNA VARIEGATA	51030903	LACUNA	|
51031001	LITTORINA	51031001	LITTORINA	
5103100101	LITTORINA SITKANA	5103100101	LITTORINA SITKANA	*
5103100104	LITTORINA SCUTULATA	5103100104	LITTORINA SCUTULATA	*

(continued)

TABLE B-1 (continued)

51032001	ALVINIA	51032001	ALVINIA	
51032004	BARLEEIA	51032004	BARLEEIA	
5103200401	BARLEEIA HALIOTIPHIL	51032004	BARLEEIA	
51032005	RISSOINA	51032005	RISSOINA	
5103210101	NAME NOT FOUND	51032101	ASSIMINEA	
51033599	NAME NOT FOUND	510335	VERMETIDAE	
5103359999	NAME NOT FOUND	510335	VERMETIDAE	
51034601	BITTIUM	51034601	BITTIUM	
5103460103	BITTIUM ESCHRICHTII	51034601	BITTIUM	
51034602	CERITHIOPSIS	51034602	CERITHIOPSIS	
5103620204	TRICHOTROPIS CANCELL	51034602	CERITHIOPSIS	
5103640101	CALYPTRAEA FASTIGATA	5103640101	CALYPTRAEA FASTIGATA	
51036402	CREPIDULA	51036402	CREPIDULA	
5103640204	CREPIDULA FORNICATA	51036402	CREPIDULA	
5103640298	NAME NOT FOUND	51036402	CREPIDULA	
5103640301	CREPIPATELLA LINGULA	5103640301	CREPIPATELLA LINGULA	
51036604	VELUTINA	51036604	VELUTINA	
5103660409	VELUTINA LAEVIGATA	51036604	VELUTINA	
5105010206	OCENEBRA LURIDA	5105010206	OCENEBRA LURIDA	
51050105	NUCELLA	51050105	NUCELLA	
5105010501	NUCELLA CANALICULATA	5105010501	NUCELLA CANALICULATA	
5105010502	NUCELLA LAMELLOSA	5105010502	NUCELLA LAMELLOSA	
5105010503	NUCELLA EMARGINATA	5105010503	NUCELLA EMARGINATA	*
5105010802	NAME NOT FOUND	51050105	NUCELLA	
5105010803	NAME NOT FOUND	51050105	NUCELLA	
5105030101	AMPHISSA COLUMBIANA	5105030101	AMPHISSA COLUMBIANA	
51050302	MITRELLA	51050302	MITRELLA	
5105030204	MITRELLA GOULDI	5105030204	MITRELLA GOULDI	
5105030206	MITRELLA CARINATA	5105030206	MITRELLA CARINATA	
5105040201	SEARLESIA DIRA	5105040201	SEARLESIA DIRA	*
5107	GASTROPODA EUTHYNEUR	5107	GASTROPODA EUTHYNEUR	
51080101	ODOSTOMIA	51080101	ODOSTOMIA	
51080102	TURBONILLA	51080102	TURBONILLA	
511004	SCAPHANDRIDAE	511004	SCAPHANDRIDAE	
51100402	CYLICHNA	511004	SCAPHANDRIDAE	
5114020101	SIPHONARIA THERSITES	5114020101	SIPHONARIA THERSITES	
51140401	PHYTIA	51140401	PHYTIA	
5127	NUDIBRANCHIA	5127	NUDIBRANCHIA	
5130030301	ARCHIDORIS MONTEREYE	5130030301	ARCHIDORIS MONTEREYE	
51310504	ONCHIDORIS	51310504	ONCHIDORIS	
5131050401	ONCHIDORIS BILAMELLA	51310504	ONCHIDORIS	
514203	AEOLIDIIDAE	514203	AEOLIDIIDAE	
5143010101	ONCHIDELLA BOREALIS	5143010101	ONCHIDELLA BOREALIS	*
53	POLYPLACOPHORA	53	POLYPLACOPHORA	
5303	NEOLORICATA ISCHNOCH	5303	NEOLORICATA ISCHNOCH	
530302	ISCHNOCHITONIDAE	530302	ISCHNOCHITONIDAE	
5303020101	BASILIOCHITON FLECTE	5303020101	BASILIOCHITON FLECTE	
5303020201	CYANOPLAX DENTIENS	5303020201	CYANOPLAX DENTIENS	*

(continued)

TABLE B-1 (continued)

5303020601	TONICELLA INSIGNIS	5303020601	TONICELLA INSIGNIS	
5303020602	TONICELLA LINEATA	5303020602	TONICELLA LINEATA	
5303020701	LEPIDOZONA MERTENSII	5303020701	LEPIDOZONA MERTENSII	
5303020703	LEPIDOZONA COOPERI	5303020703	LEPIDOZONA COOPERI	
5303060102	CHAETOPLEURA GEMMA	5303060102	CHAETOPLEURA GEMMA	
53030703	KATHARINA	53030703	KATHARINA	|*
5303070301	KATHARINA TUNICATA	53030703	KATHARINA	|
53030704	MOPALIA	53030704	MOPALIA	
5303070401	MOPALIA CILIATA	5303070401	MOPALIA CILIATA	
5303070404	MOPALIA HINDSI	5303070404	MOPALIA HINDSI	
5303070407	MOPALIA LIGNOSA	5303070407	MOPALIA LIGNOSA	
5303070408	MOPALIA MUCOSA	5303070408	MOPALIA MUCOSA	
5303070497	NAME NOT FOUND	53030704	MOPALIA	
5303070499	NAME NOT FOUND	53030704	MOPALIA	
5304010101	CRYPTOCHITON STELLER	5304010101	CRYPTOCHITON STELLER	
55	BIVALVIA	55	BIVALVIA	
5502020201	NUCULA TENUIS	5502020201	NUCULA TENUIS	
5507	MYTILOIDA	5507	MYTILOIDA	
550701	MYTILIDAE	550701	MYTILIDAE	
55070101	MYTILUS	55070101	MYTILUS	
5507010101	MYTILUS EDULIS	5507010101	MYTILUS EDULIS	*
5507010102	MYTILUS CALIFORNIANU	5507010102	MYTILUS CALIFORNIANU	*
55070104	MUSCULUS	55070104	MUSCULUS	
5507010401	MUSCULUS NIGER	5507010401	MUSCULUS NIGER	
5507010402	MUSCULUS DISCORS	5507010402	MUSCULUS DISCORS	
5507010410	MUSCULUS PYGMAEUS	5507010410	MUSCULUS PYGMAEUS	
5507010499	NAME NOT FOUND	55070104	MUSCULUS	
55070106	MODIOLUS	55070106	MODIOLUS	
5507010603	MODIOLUS RECTUS	55070106	MODIOLUS	
5507010699	NAME NOT FOUND	55070106	MODIOLUS	
5507011101	ADULA CALIFORNIENSIS	5507011101	ADULA CALIFORNIENSIS	
55070199	NAME NOT FOUND	550701	MYTILIDAE	
5507019999	NAME NOT FOUND	550701	MYTILIDAE	
5509090103	PODODESMUS CEPIO	5509090103	PODODESMUS CEPIO	
5515070101	LASAEA CISTULA	551507	ERYCINIDAE	
5515079999	NAME NOT FOUND	551507	ERYCINIDAE	
55150801	KELLIA	55150801	KELLIA	
5515100102	MYSELLA TUMIDA	5515100102	MYSELLA TUMIDA	
5515250201	TRESUS CAPAX	5515250201	TRESUS CAPAX	
5515290201	SOLEN SICARIUS	5515290201	SOLEN SICARIUS	
55153101	MACOMA	55153101	MACOMA	
5515310116	MACOMA BALTHICA	5515310116	MACOMA BALTHICA	
5515310117	MACOMA SECTA	5515310117	MACOMA SECTA	
55154701	TRANSENNELLA	55154701	TRANSENNELLA	
5515470101	TRANSENNELLA TANTILL	55154701	TRANSENNELLA	
5515470201	SAXIDOMUS GIGANTEA	5515470201	SAXIDOMUS GIGANTEA	
5515470701	PROTOTHACA STAMINEA	5515470701	PROTOTHACA STAMINEA	
5516	MYOIDA	5516	MYOIDA	

(continued)

TABLE B-1 (continued)

5517060201	HIATELLA ARCTICA	5517060201	HIATELLA ARCTICA	
5517060203	HIATELLA GLACIANA	5517060203	HIATELLA GLACIANA	
5517060204	NAME NOT FOUND	55170602	HIATELLA	
551801	PHOLADIDAE	551801	PHOLADIDAE	
5518010101	ZIRFAEA PILSBURYI	551801	PHOLADIDAE	
55180102	PENITELLA	55180102	PENITELLA	
5518010201	PENITELLA PENITA	55180102	PENITELLA	
5518010299	NAME NOT FOUND	55180102	PENITELLA	
55180107	NETASTOMA	55180107	NETASTOMA	
55180199	NAME NOT FOUND	551801	PHOLADIDAE	
5520050101	ENTODESMA SAXICOLUM	5520050101	ENTODESMA SAXICOLUM	
5520050202	LYONSIA CALIFORNICA	5520050202	LYONSIA CALIFORNICA	
60	ARTHROPODA PYCNOGONI	60	ARTHROPODA PYCNOGONI	
6001	PANTOPODA	6001	PANTOPODA	
6001010198	NAME NOT FOUND	60010101	NYMPHON	
6001010199	NAME NOT FOUND	60010101	NYMPHON	
600104	AMMOTHEIDAE	600104	AMMOTHEIDAE	
60010402	ACHELIA	60010402	ACHELIA	
6001040201	ACHELIA CHELATA	6001040201	ACHELIA CHELATA	
6001040204	ACHELIA NUDIUSCULA	6001040204	ACHELIA NUDIUSCULA	
6001040299	NAME NOT FOUND	60010402	ACHELIA	
6001040301	AMMOTHELLA TUBERCULA	6001040301	AMMOTHELLA TUBERCULA	
600106	PHOXICHILIDIIDAE	600106	PHOXICHILIDIIDAE	
6001060102	PHOXICHILIDIUM FEMOR	6001060102	PHOXICHILIDIUM FEMOR	
60010603	HALOSOMA	60010603	HALOSOMA	
6001060301	HALOSOMA VIRIDINTEST	6001060301	HALOSOMA VIRIDINTEST	
6001060302	HALOSOMA COMPACTUM	6001060302	HALOSOMA COMPACTUM	
600108	PYCNOGONIDAE	600108	PYCNOGONIDAE	
6001080101	PYCNOGONUM STEARNSI	6001080101	PYCNOGONUM STEARNSI	
6001080102	PYCNOGONUM RICKETTSI	6001080102	PYCNOGONUM RICKETTSI	
61	ARTHROPODA MANDIBULA	61	ARTHROPODA MANDIBULA	
6110	OSTRACODA	6110	OSTRACODA	
6110999999	NAME NOT FOUND	6110	OSTRACODA	
6111	OSTRACODA MYODOCOPA	6111	OSTRACODA MYODOCOPA	
6117	COPEPODA	6117	COPEPODA	
6117999999	NAME NOT FOUND	6117	COPEPODA	
6130	CIRRIPEDIA	6130	CIRRIPEDIA	
6132010201	POLLICIPES POLYMERUS	6132010201	POLLICIPES POLYMERUS	
6134	CIRRIPEDIA THORACICA	6134	CIRRIPEDIA THORACICA	
6134010101	CHTHAMALUS DALLI	6134010101	CHTHAMALUS DALLI	*
613402	BALANIDAE	613402	BALANIDAE	
61340201	BALANUS	61340201	BALANUS	
6134020101	BALANUS BALANOIDES	6134020101	BALANUS BALANOIDES	
6134020103	BALANUS CARIOSUS	6134020103	BALANUS CARIOSUS	*
6134020104	BALANUS CRENATUS	6134020104	BALANUS CRENATUS	
6134020107	BALANUS GLANDULA	6134020107	BALANUS GLANDULA	*
6134020110	BALANUS NUBILIS	6134020110	BALANUS NUBILIS	
6134020111	BALANUS ROSTRATUS	6134020111	BALANUS ROSTRATUS	

(continued)

TABLE B-1 (continued)

61450101	NEBALIA	61450101	NEBALIA	
6154	PERACARIDA CUMACEA	6154	PERACARIDA CUMACEA	
6154010104	LAMPROPS CARINATA	6154010104	LAMPROPS CARINATA	
615408	NANNASTACIDAE	615408	NANNASTACIDAE	
61540801	CUMELLA	615408	NANNASTACIDAE	
6154080102	CUMELLA VULGARIS	615408	NANNASTACIDAE	
61540903	LEPTOCUMA/PSEUDOLEPT	61540903	LEPTOCUMA/PSEUDOLEPT	
6157	PERACARIDA TANAIDACE	6157	PERACARIDA TANAIDACE	
615701	TANAIDAE	615701	TANAIDAE	
6157010301	ANATANAIS NORMANI	6157010301	ANATANAIS NORMANI	*
6157010401	PANCOLUS CALIFORNIEN	6157010401	PANCOLUS CALIFORNIEN	
6157010501	PSEUDOTANAIS OCULATU	6157010501	PSEUDOTANAIS OCULATU	
61570201	LEPTOCHELIA (TANAI	61570201	LEPTOCHELIA (TANAI	¦*
6157020101	LEPTOCHELIA SAVIGNYI	6157020101	LEPTOCHELIA SAVIGNYI	¦
6157020103	LEPTOCHELIA DUBIA	6157020103	LEPTOCHELIA DUBIA	¦
6157020199	NAME NOT FOUND	61570201	LEPTOCHELIA (TANAI	¦
6160010501	PARANTHURA ELEGANS	616001	ANTHURIDAE	
6160019999	NAME NOT FOUND	616001	ANTHURIDAE	
6161010101	CIROLANA KINCAIDI	6161010101	CIROLANA KINCAIDI	
6161010102	CIROLANA HARFORDI	6161010102	CIROLANA HARFORDI	
616102	SPHAEROMATIDAE	616102	SPHAEROMATIDAE	
61610203	GNORIMOSPHAEROMA	61610203	GNORIMOSPHAEROMA	
6161020301	GNORIMOSPHAEROMA ORE	61610203	GNORIMOSPHAEROMA	
61610204	EXOSPHAEROMA	61610204	EXOSPHAEROMA	
6161020401	EXOSPHAEROMA AMPLICA	6161020401	EXOSPHAEROMA AMPLICA	*
6161020402	EXOSPHAEROMA MEDIA	6161020402	EXOSPHAEROMA MEDIA	
6161020403	EXOSPHAEROMA RHOMBUR	6161020403	EXOSPHAEROMA RHOMBUR	
6161020404	EXOSPHAEROMA OCTONCU	6161020404	EXOSPHAEROMA OCTONCU	
61610205	DYNAMENELLA	61610205	DYNAMENELLA	
6161020501	DYNAMENELLA SHEARERI	6161020501	DYNAMENELLA SHEARERI	*
6161020502	DYNAMENELLA GLABRA	6161020502	DYNAMENELLA GLABRA	
6161020599	NAME NOT FOUND	61610205	DYNAMENELLA	
61610501	LIMNORIA	61610501	LIMNORIA	
6161050101	LIMNORIA LIGNORUM	6161050101	LIMNORIA LIGNORUM	
6161050102	LIMNORIA ALGARUM	6161050102	LIMNORIA ALGARUM	
6162	PERACARIDA ISOPODA V	6162	PERACARIDA ISOPODA V	
61620202	SYNIDOTEA	61620202	SYNIDOTEA	
6162020201	SYNIDOTEA BICUSPIDA	6162020201	SYNIDOTEA BICUSPIDA	
6162020208	SYNIDOTEA RITTERI	6162020208	SYNIDOTEA RITTERI	
6162020209	SYNIDOTEA PETTIBONEA	6162020209	SYNIDOTEA PETTIBONEA	
6162020210	SYNIDOTEA ANGULATA	6162020210	SYNIDOTEA ANGULATA	
6162020296	NAME NOT FOUND	61620202	SYNIDOTEA	
61620203	IDOTEA	61620203	IDOTEA	
6162020301	IDOTEA RESECATA	6162020301	IDOTEA RESECATA	
6162020302	IDOTEA WOSNESENSKII	6162020302	IDOTEA WOSNESENSKII	*
6162020303	IDOTEA FEWKESI	6162020303	IDOTEA FEWKESI	
6162020304	IDOTEA RUFESCENS	6162020304	IDOTEA RUFESCENS	
6162020307	IDOTEA ACULEATA	6162020307	IDOTEA ACULEATA	

(continued)

TABLE B-1 (continued)

6162020311	IDOTEA UROTOMA	6162020311	IDOTEA UROTOMA
6162020312	IDOTEA SCHMITTI	6162020312	IDOTEA SCHMITTI
6162020313	IDOTEA MONTEREYENSIS	6162020313	IDOTEA MONTEREYENSIS
6162020396	NAME NOT FOUND	61620203	IDOTEA
6162020398	NAME NOT FOUND	61620203	IDOTEA
6162020399	NAME NOT FOUND	61620203	IDOTEA
61630201	IANIROPSIS	61630201	IANIROPSIS
6163020101	IANIROPSIS KINCAIDI	6163020101	IANIROPSIS KINCAIDI
6163020102	IANIROPSIS PUGETTENS	6163020102	IANIROPSIS PUGETTENS
6163020103	IANIROPSIS ANALOGA	6163020103	IANIROPSIS ANALOGA
6163020106	IANIROPSIS TRIDENS	6163020106	IANIROPSIS TRIDENS
6163020198	NAME NOT FOUND	61630201	IANIROPSIS
61630203	JANIRALATA	61630203	JANIRALATA
61631101	JAEROPSIS	61631101	JAEROPSIS
6163110101	JAEROPSIS LOBATA	6163110101	JAEROPSIS LOBATA
6163110102	JAEROPSIS SETOSA	6163110102	JAEROPSIS SETOSA
6163110103	JAEROPSIS DUBIA	6163110103	JAEROPSIS DUBIA
61631201	MUNNA	61631201	MUNNA
6163120101	MUNNA STEPHENSENI	6163120101	MUNNA STEPHENSENI
6163120102	MUNNA CHROMATOCEPHAL	6163120102	MUNNA CHROMATOCEPHAL
6163120103	MUNNA UBIQUITA	6163120103	MUNNA UBIQUITA
6163120199	NAME NOT FOUND	61631201	MUNNA
6165030301	CRYPTOTHIR BALANI	6165030301	CRYPTOTHIR BALANI
616504	BOPYRIDAE	616504	BOPYRIDAE
6165040303	PSEUDIONE GIARDI	616504	BOPYRIDAE
6166010101	LIGIA PALLASI	6166010101	LIGIA PALLASI
6168	PERACARIDA AMPHIPODA	6168	PERACARIDA AMPHIPODA
6169	PERACARIDA AMPHIPODA	6169	GAMMARID AMPHIPOD
6169030202	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
616904	AMPITHOIDAE	6169	GAMMARID AMPHIPOD
61690401	AMPHITHOE	6169	GAMMARID AMPHIPOD
6169040104	AMPHITHOE SIMULANS	6169	GAMMARID AMPHIPOD
6169040118	AMPHITHOE LACERTOSA	6169	GAMMARID AMPHIPOD
6169040120	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169040197	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169040198	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169040298	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169060202	AOROIDES COLUMBIAE	6169	GAMMARID AMPHIPOD
6169090101	ATYLUS TRIDENS	6169	GAMMARID AMPHIPOD
6169090108	ATYLUS LEVIDENSUS	6169	GAMMARID AMPHIPOD
6169090199	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
61691202	CALLIOPIUS	6169	GAMMARID AMPHIPOD
6169120901	OLIGOCHINUS LIGHTI	6169	GAMMARID AMPHIPOD
6169121001	CALLIOPIELLA PRATTI	6169	GAMMARID AMPHIPOD
61691502	COROPHIUM	6169	GAMMARID AMPHIPOD
6169150201	COROPHIUM ACHERUSICU	6169	GAMMARID AMPHIPOD
6169150208	COROPHIUM BREVIS	6169	GAMMARID AMPHIPOD
6169150211	COROPHIUM INSIDIOSUM	6169	GAMMARID AMPHIPOD

(continued)

TABLE B-1 (continued)

6169170301	POLYCHERIA OSBORNI	6169	GAMMARID AMPHIPOD
6169200198	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
61692010	PARAMOERA	6169	GAMMARID AMPHIPOD
6169201097	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169201098	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
61692012	PONTOGENEIA	6169	GAMMARID AMPHIPOD
6169201203	PONTOGENEIA INERMIS	6169	GAMMARID AMPHIPOD
6169201204	PONTOGENEIA INTERMED	6169	GAMMARID AMPHIPOD
6169201297	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169201298	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169201299	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
616921	GAMMARIDAE	6169	GAMMARID AMPHIPOD
6169210106	ANISOGAMMARUS PUGETT	6169	GAMMARID AMPHIPOD
61692110	MELITA (AMPHIPODA	6169	GAMMARID AMPHIPOD
6169211005	MELITA CALIFORNICA	6169	GAMMARID AMPHIPOD
61692201	EOHAUSTORIUS	6169	GAMMARID AMPHIPOD
6169230301	NAJNA CONSILIORUM	6169	GAMMARID AMPHIPOD
616924	HYALIDAE	6169	GAMMARID AMPHIPOD
6169240101	ALLORCHESTES MOLEOLU	6169	GAMMARID AMPHIPOD
6169240105	ALLORCHESTES ANGUSTU	6169	GAMMARID AMPHIPOD
6169240106	ALLORCHESTES CAPRELL	6169	GAMMARID AMPHIPOD
6169240107	ALLORCHESTES ANCEPS	6169	GAMMARID AMPHIPOD
61692402	HYALE	6169	GAMMARID AMPHIPOD
6169240201	HYALE RUBRA	6169	GAMMARID AMPHIPOD
6169240204	HYALE PLUMULOSA	6169	GAMMARID AMPHIPOD
6169240205	HYALE PUGETTENSIS	6169	GAMMARID AMPHIPOD
6169240207	HYALE GRANDICORNIS	6169	GAMMARID AMPHIPOD
6169240299	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169240401	PARALLORCHESTES OCHO	6169	GAMMARID AMPHIPOD
61692602	PHOTIS	6169	GAMMARID AMPHIPOD
6169260201	PHOTIS BREVIPES	6169	GAMMARID AMPHIPOD
6169260210	PHOTIS BIFURCATA	6169	GAMMARID AMPHIPOD
6169260298	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169260299	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169260401	GAMMAROPSIS THOMPSON	6169	GAMMARID AMPHIPOD
61692702	ISCHYROCERUS	6169	GAMMARID AMPHIPOD
6169270202	ISCHYROCERUS ANGUIPE	6169	GAMMARID AMPHIPOD
6169270302	JASSA FALCATA	6169	GAMMARID AMPHIPOD
6169270399	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
61692799	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169279999	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169320199	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169342199	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169342998	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
61693499	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169371403	SYNCHELIDIUM RECTIPA	6169	GAMMARID AMPHIPOD
61694209	PARAPHOXUS	6169	GAMMARID AMPHIPOD
6169420928	PARAPHOXUS SPINOSUS	6169	GAMMARID AMPHIPOD

(continued)

TABLE B-1 (continued)

61694303	PARAPLEUSTES	6169	GAMMARID AMPHIPOD
6169430301	PARAPLEUSTES NAUTILU	6169	GAMMARID AMPHIPOD
6169430302	PARAPLEUSTES PUGETTE	6169	GAMMARID AMPHIPOD
6169430303	PARAPLEUSTES JOHANSE	6169	GAMMARID AMPHIPOD
6169481102	STENOTHOIDES BERINGI	6169	GAMMARID AMPHIPOD
6169481599	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
616951	TALITRIDAE	6169	GAMMARID AMPHIPOD
6169999992	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999993	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999994	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999995	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999996	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999997	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999998	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6169999999	NAME NOT FOUND	6169	GAMMARID AMPHIPOD
6171	PERACARIDA AMPHIPODA	6171	CAPRELLID AMPHIPOD
617101	CAPRELLIDAE	617101	CAPRELLIDAE
61710101	CERCOPS	61710101	CERCOPS
6171010102	CERCOPS COMPACTA	61710101	CERCOPS
6171010201	DEUTELLA CALIFORNICA	6171010201	DEUTELLA CALIFORNICA
6171010601	TRITELLA LAEVIS	6171010601	TRITELLA LAEVIS
6171010602	TRITELLA PILIMANA	6171010602	TRITELLA PILIMANA
61710107	CAPRELLA (AMPHIPO	61710107	CAPRELLA (AMPHIPO
6171010706	CAPRELLA DREPANOCHIR	6171010706	CAPRELLA DREPANOCHIR
6171010708	CAPRELLA IRREGULARIS	6171010708	CAPRELLA IRREGULARIS
6171010710	CAPRELLA LAEVIUSCULA	6171010710	CAPRELLA LAEVIUSCULA
6171010713	CAPRELLA INCISA	6171010713	CAPRELLA INCISA
6171010715	CAPRELLA AUGUSTA	6171010715	CAPRELLA AUGUSTA
6171010716	CAPRELLA VERRUCOSA	6171010716	CAPRELLA VERRUCOSA
6171010721	CAPRELLA PUSTULATA	6171010721	CAPRELLA PUSTULATA
6171010729	CAPRELLA GREENLYI	6171010729	CAPRELLA GREENLYI
6171010799	NAME NOT FOUND	61710107	CAPRELLA (AMPHIPO
6175	EUCARIDA DECAPODA(AR	6175	EUCARIDA DECAPODA(AR
6179	EUCARIDA DECAPODA PL	6179	EUCARIDA DECAPODA PL
6179160201	SPIRONTOCARIS PRIONO	6179160201	SPIRONTOCARIS PRIONO
6179160511	HEPTACARPUS STIMPSON	6179160511	HEPTACARPUS STIMPSON
618306	PAGURIDAE	618306	PAGURIDAE
61830602	PAGURUS (DECAPODA)	61830602	PAGURUS (DECAPODA)
6183060208	PAGURUS CAURINUS	6183060208	PAGURUS CAURINUS
6183060209	PAGURUS BERINGANUS	6183060209	PAGURUS BERINGANUS
6183060211	PAGURUS GRANOSIMANUS	6183060211	PAGURUS GRANOSIMANUS
6183060213	PAGURUS HIRSUTIUSCUL	6183060213	PAGURUS HIRSUTIUSCUL
6183060301	ELASSOCHIRUS TENUIMA	6183060301	ELASSOCHIRUS TENUIMA
618308	LITHODIDAE	618308	LITHODIDAE
6183080401	OEDIGNATHUS INERMIS	6183080401	OEDIGNATHUS INERMIS
6183081101	CRYPTOLITHODES SITCH	6183081101	CRYPTOLITHODES SITCH
6183120202	PACHYCHELES RUDIS	6183120202	PACHYCHELES RUDIS
618701	MAJIDAE	618701	MAJIDAE

(continued)

TABLE B-1 (continued)

6187010101	OREGONIA GRACILIS	6187010101	OREGONIA GRACILIS	
61870105	PUGETTIA (DECAPODA	61870105	PUGETTIA (DECAPODA	
6187010502	PUGETTIA RICHII	6187010502	PUGETTIA RICHII	
6187010503	PUGETTIA GRACILIS	6187010503	PUGETTIA GRACILIS	*
6188020101	TELMESSUS CHEIRAGONU	6188020101	TELMESSUS CHEIRAGONU	
61880301	CANCER	61880301	CANCER	
6188030101	CANCER PRODUCTUS	6188030101	CANCER PRODUCTUS	
6188030105	CANCER GRACILIS	6188030105	CANCER GRACILIS	
6188030106	CANCER OREGONENSIS	6188030106	CANCER OREGONENSIS	*
6189	EUCARIDA DECAPODA PL	6189	EUCARIDA DECAPODA PL	
6189020301	FABIA SUBQUADRATA	618902	XANTHIDAE	
61890204	NAME NOT FOUND	618902	XANTHIDAE	
618906	PINNOTHERIDAE	618906	PINNOTHERIDAE	
6189060299	NAME NOT FOUND	618906	PINNOTHERIDAE	
61890701	HEMIGRAPSUS	61890701	HEMIGRAPSUS	
6189070101	HEMIGRAPSUS NUDUS	6189070101	HEMIGRAPSUS NUDUS	
6189070102	HEMIGRAPSUS OREGONEN	6189070102	HEMIGRAPSUS OREGONEN	
6208	COLLEMBOLA	6208	COLLEMBOLA	
6302	COLEOPTERA	6302	COLEOPTERA	
65	INSECTA IV	65	INSECTA IV	
6501	DIPTERA	6501	DIPTERA	
650508	CHIRONOMIDAE	650508	CHIRONOMIDAE	
651802	DOLICHOPODIDAE	651802	DOLICHOPODIDAE	
653801	EPHYDRIDAE	653801	EPHYDRIDAE	
72	SIPUNCULIDA	72	SIPUNCULIDA	
7200020104	GOLFINGIA PUGETTENSI	7200020104	GOLFINGIA PUGETTENSI	
7200040101	PHASCOLOSOMA AGASSIZ	7200040101	PHASCOLOSOMA AGASSIZ	
78	ECTOPROCTA	78	ECTOPROCTA	
78030201	FLUSTRELLA	78030201	FLUSTRELLA	
7809	GYMNOLAEMATA CYCLOST	7809	GYMNOLAEMATA CYCLOST	
78090101	CRISIA	78090101	CRISIA	
78090102	BICRISIA	78090102	BICRISIA	
7809010201	BICRISIA EDWARDSIANA	78090102	BICRISIA	
78090103	FILICRISIA	78090103	FILICRISIA	
78120101	HETEROPORA (ECTOP	78120101	HETEROPORA (ECTOP	
7812010199	NAME NOT FOUND	78120101	HETEROPORA (ECTOP	
78150401	MEMBRANIPORA	78150401	MEMBRANIPORA	
7815040101	MEMBRANIPORA MEMBRAN	78150401	MEMBRANIPORA	
78160201	HIPPOTHOA	78160201	HIPPOTHOA	
7816020101	HIPPOTHOA HYALINA	78160201	HIPPOTHOA	
78161101	MICROPORELLA	78161101	MICROPORELLA	
8104	ASTEROIDEA	8104	ASTEROIDEA	
8114040105	HENRICIA LEVIUSCULA	8114040105	HENRICIA LEVIUSCULA	
8117	NAME NOT FOUND	811703	ASTERIIDAE	
811703	ASTERIIDAE	811703	ASTERIIDAE	
8117030409	LEPTASTERIAS HEXACTI	8117030409	LEPTASTERIAS HEXACTI	*
8117030499	NAME NOT FOUND	81170304	LEPTASTERIAS	
8129	OPHIUROIDEA OPHIURID	8129	OPHIUROIDEA OPHIURID	

(continued)

TABLE B-1 (continued)

812903	AMPHIURIDAE	812903	AMPHIURIDAE
8129030299	NAME NOT FOUND	81290302	AMPHIPHOLIS
8129030302	DIAMPHIODIA OCCIDENT	8129030302	DIAMPHIODIA OCCIDENT
8129030303	DIAMPHIODIA PERIERCT	8129030303	DIAMPHIODIA PERIERCT
81490302	STRONGYLOCENTROTUS	81490302	STRONGYLOCENTROTUS
8149030201	STRONGYLOCENTROTUS D	81490302	STRONGYLOCENTROTUS
8170	HOLOTHUROIDEA	8170	HOLOTHUROIDEA
817206	CUCUMARIIDAE	817206	CUCUMARIIDAE
8172060110	CUCUMARIA MINIATA	8172060110	CUCUMARIA MINIATA
8172060113	CUCUMARIA PSEUDOCURA	8172060113	CUCUMARIA PSEUDOCURA
8172060202	EUPENTACTA QUINQUESE	8172060202	EUPENTACTA QUINQUESE
8178010203	LEPTOSYNAPTA CLARKI	8178010203	LEPTOSYNAPTA CLARKI
84	UROCHORDATA	84	UROCHORDATA
8404040102	CHELYOSOMA PRODUCTUM	8404040102	CHELYOSOMA PRODUCTUM
8406	ASCIDIACEA PLEUROGON	8406	ASCIDIACEA PLEUROGON
840601	STYELIDAE	840601	STYELIDAE
8406020101	PYURA HAUSTOR	8406020101	PYURA HAUSTOR
8406020203	BOLTENIA VILLOSA	8406020203	BOLTENIA VILLOSA
8784010101	GOBIESOX MAEANDRICUS	8784010101	GOBIESOX MAEANDRICUS
88	GNATHOSTOMATA II	88	GNATHOSTOMATA II
8831022401	OLIGOCOTTUS MACULOSU	8831022401	OLIGOCOTTUS MACULOSU
88421221	ULVARIA	88421221	ULVARIA
884213	PHOLIDIDAE (GUNNELS)	884213	PHOLIDIDAE (GUNNELS)
999999	NAME NOT FOUND	ER	

TABLE B-2. TAXONOMIC DICTIONARY FOR INTERTIDAL SOFT SUBSTRATES

07	BACILLARIOPHYTA	07	BACILLARIOPHYTA	
0701	BACILLARIOPHYCEAE	07	BACILLARIOPHYTA	
0703	BACILLARIOPHYCEAE PE	07	BACILLARIOPHYTA	
0801	CHLOROPHYCEAE	0801	CHLOROPHYCEAE	
0804010103	PRASIOLA MERIDIONALI	0804010103	PRASIOLA MERIDIONALIS	
08050102	ULOTHRIX	08050102	ULOTHRIX	|*
08050201	MONOSTROMA	08050201	MONOSTROMA	|
0805020105	MONOSTROMA FUSCUM	08050201	MONOSTROMA	|
080503	ULVACEAE	080503	ULVACEAE	|
08050303	ENTEROMORPHA	08050303	ENTEROMORPHA	|
0805030301	ENTEROMORPHA CLATHRA	0805030301	ENTEROMORPHA CLATHRATA	|
0805030302	ENTEROMORPHA COMPRES	0805030302	ENTEROMORPHA COMPRESSA	|
0805030306	ENTEROMORPHA LINZA	0805030306	ENTEROMORPHA LINZA	|
0805030314	ENTEROMORPHA CRINITA	0805030314	ENTEROMORPHA CRINITA	|
0805030317	ENTEROMORPHA INTESTI	0805030317	ENTEROMORPHA INTESTINALIS	|
0805030318	ENTEROMORPHA PROLIFE	0805030318	ENTEROMORPHA PROLIFERA	|
0805030319	ENTEROMORPHA FLEXUOS	0805030319	ENTEROMORPHA FLEXUOSA	|
08050305	ULVA (CHLOROPHYCE	08050305	ULVA (CHLOROPHYCEAE)	|
0805030502	ULVA RIGIDA	08050305	ULVA (CHLOROPHYCEAE)	|
0805030594	NAME NOT FOUND	08050305	ULVA (CHLOROPHYCEAE)	|
0807010202	SPONGOMORPHA COALITA	0807010202	SPONGOMORPHA COALITA	
0807010205	SPONGOMORPHA MERTENS	0807010205	SPONGOMORPHA MERTENSII	
08070103	UROSPORA	08070103	UROSPORA	
0807010301	UROSPORA WORMSKIOLDI	0807010301	UROSPORA WORMSKIOLDII	
0807010302	UROSPORA MIRABILIS	0807010302	UROSPORA MIRABILIS	
0808010101	CHAETOMORPHA CANNABI	0808010101	CHAETOMORPHA CANNABINA	
08080102	CLADOPHORA	08080102	CLADOPHORA	
08080103	RHIZOCLONIUM	08080103	RHIZOCLONIUM	
0808010301	RHIZOCLONIUM IMPLEXU	0808010301	RHIZOCLONIUM IMPLEXUM	
0808010302	RHIZOCLONIUM RIPARIU	0808010302	RHIZOCLONIUM RIPARIUM	
0809020102	BRYOPSIS PLUMOSA	0809020102	BRYOPSIS PLUMOSA	
15	PHAEOPHYTA	15	PHAEOPHYTA	
15020109	FELDMANNIA	15020109	FELDMANNIA	
15080201	LAMINARIA	15080201	LAMINARIA	
15090201	DESMARESTIA	15090201	DESMARESTIA	
1510010202	FUCUS DISTICHUS	1510010202	FUCUS DISTICHUS	
1510030201	CYSTOSEIRA GEMINATA	1510030201	CYSTOSEIRA GEMINATA	
1512010201	PETALONIA FASCIA	1512010201	PETALONIA FASCIA	
16	RHODOPHYTA	16	RHODOPHYTA	
1601	RHODOPHYCEAE	1601	RHODOPHYCEAE	
1605010501	SMITHORA NAIADUM	1605010501	SMITHORA NAIADUM	
16050202	PORPHYRA	16050202	PORPHYRA	
16080501	PLOCAMIUM (RHODOPH	16080501	PLOCAMIUM (RHODOPHYTA)	
16080701	GRACILARIA	16080701	GRACILARIA	
1608070102	GRACILARIA VERRUCOSA	16080701	GRACILARIA	

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[*] Starred species or groups are important taxa which were used for cluster analyses and, in some cases, population parameter analyses.

TABLE B-2 (continued)

1608090101	AHNFELTIA PLICATA	1608090101	AHNFELTIA PLICATA	
16081002	GIGARTINA	16081002	GIGARTINA	
1608100203	GIGARTINA PAPILLATA	16081002	GIGARTINA	
16081003	IRIDAEA	16081003	IRIDAEA	
1609110101	CHOREOCOLAX POLYSIPH	1609110101	CHOREOCOLAX POLYSIPHONIAE	
1610020203	RHODYMENIA PALMATA	1610020203	RHODYMENIA PALMATA	
16110101	ANTITHAMNION	16110101	ANTITHAMNION	
16110104	CERAMIUM	16110104	CERAMIUM	
1611010408	CERAMIUM PACIFICUM	1611010408	CERAMIUM PACIFICUM	
1611010413	CERAMIUM WASHINGTONI	1611010413	CERAMIUM WASHINGTONIENSE	
1611010489	NAME NOT FOUND	16110104	CERAMIUM	
1611010495	NAME NOT FOUND	16110104	CERAMIUM	
1611010499	NAME NOT FOUND	16110104	CERAMIUM	
16110113	MICROCLADIA	16110113	MICROCLADIA	
1611011301	MICROCLADIA BOREALIS	16110113	MICROCLADIA	
161102	DELESSERIACEAE	161102	DELESSERIACEAE	
1611020901	GONIMOPHYLLUM SKOTTS	1611020901	GONIMOPHYLLUM SKOTTSBERGII	
1611021501	POLYNEURA LATISSIMA	1611021501	POLYNEURA LATISSIMA	
16110224	HYMENENA	16110224	HYMENENA	
16110401	POLYSIPHONIA	16110401	POLYSIPHONIA	
1611040101	POLYSIPHONIA HENDRYI	1611040101	POLYSIPHONIA HENDRYI	
1611040103	POLYSIPHONIA PACIFIC	1611040103	POLYSIPHONIA PACIFICA	
1611040114	POLYSIPHONIA PANICUL	1611040114	POLYSIPHONIA PANICULATA	
16110402	PTEROSIPHONIA	16110402	PTEROSIPHONIA	
1611040202	PTEROSIPHONIA BIPINN	1611040202	PTEROSIPHONIA BIPINNATA	
1611040203	PTEROSIPHONIA DENDRO	1611040203	PTEROSIPHONIA DENDROIDEA	
16110406	ODONTHALIA	16110406	ODONTHALIA	
1611040603	ODONTHALIA FLOCCOSA	16110406	ODONTHALIA	
16110412	HERPOSIPHONIA	16110412	HERPOSIPHONIA	
33	ANTHOPHYTA II	33	ANTHOPHYTA II	
33260101	ZOSTERA	33260101	ZOSTERA	¦*
3326010101	ZOSTERA MARINA	33260101	ZOSTERA	¦
36	PORIFERA	36	PORIFERA	
37	CNIDARIA	37	CNIDARIA	
3701	HYDROZOA	3701	HYDROZOA	
3702	HYDROZOA HYDROIDA	3702	HYDROZOA HYDROIDA	
37030601	CORYNE	37030601	CORYNE	
37040102	OBELIA	37040102	OBELIA	
37040711	AGLAOPHENIA	37040711	AGLAOPHENIA	
3740	ANTHOZOA	3740	ANTHOZOA	
3758	ZOANTHARIA ACTINIARI	3758	ZOANTHARIA ACTINIARIA	
3758999999	NAME NOT FOUND	3758	ZOANTHARIA ACTINIARIA	
37590401	HALCAMPA	375904	HALCAMPIDAE	
3759040101	HALCAMPA DECEMTENTAC	375904	HALCAMPIDAE	
3759049999	NAME NOT FOUND	375904	HALCAMPIDAE	
37600102	ANTHOPLEURA	37600102	ANTHOPLEURA	
3760010201	ANTHOPLEURA ELEGANTI	37600102	ANTHOPLEURA	
37600103	EPIACTIS	37600103	EPIACTIS	

(continued)

TABLE B-2 (continued)

3760010301	EPIACTIS PROLIFERA	37600103	EPIACTIS	
3760060101	METRIDIUM SENILE	3760060101	METRIDIUM SENILE	
39	PLATYHELMINTHES	39	PLATYHELMINTHES	
3901	TURBELLARIA	3901	TURBELLARIA	
3914020901	ITASPIELLA ARMATA	39140209	ITASPIELLA	
3914020999	NAME NOT FOUND	39140209	ITASPIELLA	
3915020103	PROCERODES PACIFICA	3915020103	PROCERODES PACIFICA	
43	RHYNCHOCOELA	43	RHYNCHOCOELA	
4302010102	TUBULANUS POLYMORPHU	4302010102	TUBULANUS POLYMORPHUS	
4303020208	CEREBRATULUS CALIFOR	4303020208	CEREBRATULUS CALIFORNIENSIS	
4306010102	EMPLECTONEMA GRACILE	4306010102	EMPLECTONEMA GRACILE	
4306010603	PARANEMERTES PEREGRI	4306010603	PARANEMERTES PEREGRINA	*
43060501	AMPHIPORUS	43060501	AMPHIPORUS	
4306050102	AMPHIPORUS BIMACULAT	43060501	AMPHIPORUS	
4306050199	NAME NOT FOUND	43060501	AMPHIPORUS	
47	NEMATODA	47	NEMATODA	
5001	POLYCHAETA	5001	POLYCHAETA	
500102	POLYNOIDAE	500102	POLYNOIDAE	
5001020402	ARCTONOE VITTATA	5001020402	ARCTONOE VITTATA	
50010205	EUNOE	50010205	EUNOE	
50010208	HARMOTHOE	50010208	HARMOTHOE	
5001020806	HARMOTHOE IMBRICATA	5001020806	HARMOTHOE IMBRICATA	*
5001020810	HARMOTHOE LUNULATA	5001020810	HARMOTHOE LUNULATA	
5001021801	LEPIDASTHENIA BERKEL	5001021801	LEPIDASTHENIA BERKELEYAE	
5001060101	PHOLOE MINUTA	5001060101	PHOLOE MINUTA	
500107	PISIONIDAE	500107	PISIONIDAE	
50010701	PISIONE	500107	PISIONIDAE	
50010799	NAME NOT FOUND	500107	PISIONIDAE	
5001080101	PALEANOTUS BELLIS	5001080101	PALEANOTUS BELLIS	
5001100501	PAREURYTHOE BOREALIS	5001100501	PAREURYTHOE BOREALIS	
500113	PHYLLODOCIDAE	500113	PHYLLODOCIDAE	
50011301	ANAITIDES/PHYLLODOCE	50011301	ANAITIDES/PHYLLODOCE	!*
5001130102	ANAITIDES GROENLANDI	5001130102	ANAITIDES GROENLANDICA	!
5001130106	ANAITIDES MACULATA	5001130106	ANAITIDES MACULATA	!
5001130198	NAME NOT FOUND	50011301	ANAITIDES/PHYLLODOCE	!
5001130199	NAME NOT FOUND	50011301	ANAITIDES/PHYLLODOCE	!
50011302	ETEONE	50011302	ETEONE	
5001130201	ETEONE CALIFORNICA	5001130201	ETEONE CALIFORNICA	
5001130203	ETEONE PACIFICA	5001130203	ETEONE PACIFICA	
5001130205	ETEONE LONGA	5001130205	ETEONE LONGA	*
5001130206	ETEONE TUBERCULATA	5001130206	ETEONE TUBERCULATA	
50011303	EULALIA	50011303	EULALIA	
5001130302	EULALIA SANGUINEA	5001130302	EULALIA SANGUINEA	
5001130304	EULALIA BILINEATA	5001130304	EULALIA BILINEATA	
5001130305	EULALIA MACROCEROS	5001130305	EULALIA MACROCEROS	
5001130306	EULALIA QUADRIOCULAT	5001130306	EULALIA QUADRIOCULATA	
5001130307	EULALIA NIGRIMACULAT	5001130307	EULALIA NIGRIMACULATA	
5001130901	HESIONURA COINEAUI	5001130901	HESIONURA COINEAUI	

(continued)

TABLE B-2 (continued)

500121	HESIONIDAE	500121	HESIONIDAE	
50012101	GYPTIS	50012101	GYPTIS	
5001210102	GYPTIS BREVIPALPA	50012101	GYPTIS	
5001210401	OPHIODROMUS PUGETTEN	5001210401	OPHIODROMUS PUGETTENSIS	
5001210501	KEFERSTEINIA CIRRATA	5001210501	KEFERSTEINIA CIRRATA	
5001210801	MICROPODARKE DUBIA	5001210801	MICROPODARKE DUBIA	
5001219899	NAME NOT FOUND	500121	HESIONIDAE	
5001219999	NAME NOT FOUND	500121	HESIONIDAE	
500122	PILARGIDAE	500122	PILARGIDAE	
5001220301	PILARGIS BERKELEYAE	500122	PILARGIDAE	
500123	SYLLIDAE	500123	SYLLIDAE	
50012301	AUTOLYTUS	50012301	AUTOLYTUS	
50012303	SYLLIS	50012303	SYLLIS	
50012305	TYPOSYLLIS	50012305	TYPOSYLLIS	
5001230501	TYPOSYLLIS ALTERNATA	5001230501	TYPOSYLLIS ALTERNATA	
5001230502	TYPOSYLLIS ARMILLARI	5001230502	TYPOSYLLIS ARMILLARIS	
5001230509	TYPOSYLLIS ADAMANTEA	5001230509	TYPOSYLLIS ADAMANTEA	
5001230510	TYPOSYLLIS HARTI	5001230510	TYPOSYLLIS HARTI	
5001230511	TYPOSYLLIS HYALINA	5001230511	TYPOSYLLIS HYALINA	
50012307	EXOGONE	50012307	EXOGONE	|*
5001230702	EXOGONE GEMMIFERA	5001230702	EXOGONE GEMMIFERA	|
5001230703	EXOGONE LOUREI	5001230703	EXOGONE LOUREI	|
5001230706	EXOGONE VERUGERA	5001230706	EXOGONE VERUGERA	|
50012308	SPHAEROSYLLIS	50012308	SPHAEROSYLLIS	
5001230805	SPHAEROSYLLIS PERIFE	5001230805	SPHAEROSYLLIS PERIFERA	
5001230806	SPHAEROSYLLIS BRANDH	5001230806	SPHAEROSYLLIS BRANDHORSTI	
5001230901	BRANIA BREVIPHARYNGE	5001230901	BRANIA BREVIPHARYNGEA	
5001231002	LANGERHANSIA HETEROC	5001231002	LANGERHANSIA HETEROCHAETA	
5001231503	SYLLIDES LONGOCIRRAT	50012315	SYLLIDES	
5001231599	NAME NOT FOUND	50012315	SYLLIDES	
5001231604	STREPTOSYLLIS LATIPA	5001231604	STREPTOSYLLIS LATIPALPA	
5001239999	NAME NOT FOUND	500123	SYLLIDAE	
500124	NEREIDAE	500124	NEREIDAE	
5001240101	CERATONEREIS PAUCIDE	5001240101	CERATONEREIS PAUCIDENTATA	
50012403	NEANTHES	50012403	NEANTHES	
5001240301	NEANTHES BRANDTI	50012403	NEANTHES	
50012404	NEREIS	50012404	NEREIS	|*
5001240403	NEREIS PELAGICA	5001240403	NEREIS PELAGICA	|
5001240404	NEREIS PROCERA	5001240404	NEREIS PROCERA	|
5001240405	NEREIS VEXILLOSA	5001240405	NEREIS VEXILLOSA	|
5001240406	NEREIS ZONATA	5001240406	NEREIS ZONATA	|
50012405	PLATYNEREIS	50012405	PLATYNEREIS	
5001240501	PLATYNEREIS BICANALI	5001240501	PLATYNEREIS BICANALICULATA	*
5001240503	PLATYNEREIS DUMERILI	5001240503	PLATYNEREIS DUMERILII	
5001240701	MICRONEREIS NANAIMOE	5001240701	MICRONEREIS NANAIMOENSIS	
50012501	NEPHTYS	50012501	NEPHTYS	
5001250103	NEPHTYS CAECA	5001250103	NEPHTYS CAECA	
5001250113	NEPHTYS CALIFORNIENS	5001250113	NEPHTYS CALIFORNIENSIS	

(continued)

TABLE B-2 (continued)

5001250119	NEPHTYS CAECOIDES	5001250119	NEPHTYS CAECOIDES	
5001250199	NAME NOT FOUND	50012501	NEPHTYS	
5001260201	SPHAERODOROPSIS MINU	5001260201	SPHAERODOROPSIS MINUTA	
500127	GLYCERIDAE	500127	GLYCERIDAE	
50012701	GLYCERA (POLYCHAE	50012701	GLYCERA (POLYCHAETA)	
5001270103	GLYCERA TESSELATA	5001270103	GLYCERA TESSELATA	
5001270104	GLYCERA AMERICANA	5001270104	GLYCERA AMERICANA	
5001270201	HEMIPODUS BOREALIS	5001270201	HEMIPODUS BOREALIS	*
50012801	GLYCINDE	50012801	GLYCINDE	
5001280101	GLYCINDE PICTA	5001280101	GLYCINDE PICTA	*
5001280103	GLYCINDE ARMIGERA	5001280103	GLYCINDE ARMIGERA	
5001280203	GONIADA BRUNNEA	5001280203	GONIADA BRUNNEA	
500129	ONUPHIDAE	500129	ONUPHIDAE	
50012901	ONUPHIS	50012901	ONUPHIS	
5001290101	ONUPHIS CONCHYLEGA	5001290101	ONUPHIS CONCHYLEGA	
5001290103	ONUPHIS IRIDESCENS	5001290103	ONUPHIS IRIDESCENS	
5001290106	ONUPHIS STIGMATIS	5001290106	ONUPHIS STIGMATIS	
5001290299	NAME NOT FOUND	50012902	DIOPATRA	
500130	EUNICIDAE	500130	EUNICIDAE	
500131	LUMBRINERIDAE	500131	LUMBRINERIDAE	
50013101	LUMBRINEREIS	50013101	LUMBRINEREIS	
5001310106	LUMBRINEREIS ZONATA	5001310106	LUMBRINEREIS ZONATA	
5001310108	LUMBRINEREIS INFLATA	5001310108	LUMBRINEREIS INFLATA	
5001310112	LUMBRINEREIS BREVICI	5001310112	LUMBRINEREIS BREVICIRRA	
500136	DORVILLEIDAE	500136	DORVILLEIDAE	
50013601	DORVILLEA/SCHISTOMER	50013601	DORVILLEA/SCHISTOMERINGOS	|*
5001360103	DORVILLEA JAPONICA	5001360103	DORVILLEA JAPONICA	|
5001360104	DORVILLEA RUDOLPHI	5001360104	DORVILLEA RUDOLPHI	|
5001360105	DORVILLEA ANNULATA	5001360105	DORVILLEA ANNULATA	|
5001360201	PROTODORVILLEA GRACI	5001360201	PROTODORVILLEA GRACILIS	
500140	ORBINIIDAE	500140	ORBINIIDAE	
5001400102	HAPLOSCOLOPLOS ELONG	5001400102	HAPLOSCOLOPLOS ELONGATUS	
50014002	NAINERIS	50014002	NAINERIS	
5001400201	NAINERIS DENDRITICA	5001400201	NAINERIS DENDRITICA	
5001400202	NAINERIS QUADRICUSPI	5001400202	NAINERIS QUADRICUSPIDA	
5001400204	NAINERIS UNCINATA	5001400204	NAINERIS UNCINATA	
50014003	SCOLOPLOS	50014003	SCOLOPLOS	
5001400301	SCOLOPLOS ARMIGER	5001400301	SCOLOPLOS ARMIGER	*
5001400302	SCOLOPLOS PUGETTENSI	5001400302	SCOLOPLOS PUGETTENSIS	*
500141	PARAONIDAE	500141	PARAONIDAE	
50014102	ARICIDEA	50014102	ARICIDEA	
5001410215	NAME NOT FOUND	50014102	ARICIDEA	
50014103	PARAONIS	50014103	PARAONIS	
5001410301	PARAONIS GRACILIS	5001410301	PARAONIS GRACILIS	
5001410304	PARAONIS LYRA	5001410304	PARAONIS LYRA	
5001410501	PARAONELLA PLATYBRAN	5001410501	PARAONELLA PLATYBRANCHIA	*
500143	SPIONIDAE	500143	SPIONIDAE	
5001430201	LAONICE CIRRATA	5001430201	LAONICE CIRRATA	

(continued)

TABLE B-2 (continued)

50014303	NERINE	50014303	NERINE	
5001430303	NERINE FOLIOSA	50014303	NERINE	
50014304	POLYDORA	50014304	POLYDORA	|*
5001430402	POLYDORA SOCIALIS	5001430402	POLYDORA SOCIALIS	|
5001430404	POLYDORA CAULLERYI	5001430404	POLYDORA CAULLERYI	|
5001430408	POLYDORA QUADRILOBAT	5001430408	POLYDORA QUADRILOBATA	|
5001430411	POLYDORA LIGNI	5001430411	POLYDORA LIGNI	|
5001430417	POLYDORA PYGIDIALIS	5001430417	POLYDORA PYGIDIALIS	|
5001430493	NAME NOT FOUND	50014304	POLYDORA	|
5001430494	NAME NOT FOUND	50014304	POLYDORA	|
5001430495	NAME NOT FOUND	50014304	POLYDORA	|
5001430496	NAME NOT FOUND	50014304	POLYDORA	|
5001430497	NAME NOT FOUND	50014304	POLYDORA	|
50014305	PRIONOSPIO	50014305	PRIONOSPIO	
5001430502	PRIONOSPIO CIRRIFERA	5001430502	PRIONOSPIO CIRRIFERA	
5001430504	PRIONOSPIO PINNATA	5001430504	PRIONOSPIO PINNATA	
5001430506	PRIONOSPIO STEENSTRU	5001430506	PRIONOSPIO STEENSTRUPI	
50014307	SPIO	50014307	SPIO	
5001430701	SPIO FILICORNIS	5001430701	SPIO FILICORNIS	
5001430703	SPIO CIRRIFERA	5001430703	SPIO CIRRIFERA	
50014308	BOCCARDIA	50014308	BOCCARDIA	
5001430801	BOCCARDIA COLUMBIANA	5001430801	BOCCARDIA COLUMBIANA	
5001430803	BOCCARDIA PROBOSCIDE	5001430803	BOCCARDIA PROBOSCIDEA	
5001430806	BOCCARDIA HAMATA	5001430806	BOCCARDIA HAMATA	
50014310	SPIOPHANES	50014310	SPIOPHANES	
5001431001	SPIOPHANES BOMBYX	5001431001	SPIOPHANES BOMBYX	
5001431003	SPIOPHANES CIRRATA	5001431003	SPIOPHANES CIRRATA	
5001431004	SPIOPHANES BERKELEYO	5001431004	SPIOPHANES BERKELEYORUM	
50014313	PYGOSPIO	50014313	PYGOSPIO	|*
5001431302	PYGOSPIO ELEGANS	50014313	PYGOSPIO	|
50014314	MALACOCEROS	50014314	MALACOCEROS	|*
5001431401	MALACOCEROS GLUTAEUS	50014314	MALACOCEROS	|
5001431501	PSEUDOPOLYDORA KEMPI	5001431501	PSEUDOPOLYDORA KEMPI	*
5001431701	PARAPRIONOSPIO PINNA	5001431701	PARAPRIONOSPIO PINNATA	
5001431801	STREBLOSPIO BENEDICT	5001431801	STREBLOSPIO BENEDICTI	
50014320	SCOLELEPIS	50014320	SCOLELEPIS	|*
5001432001	SCOLELEPIS SQUAMATA	50014320	SCOLELEPIS	|
5001432097	NAME NOT FOUND	50014320	SCOLELEPIS	|
5001432099	NAME NOT FOUND	50014320	SCOLELEPIS	|
50014401	MAGELONA	50014401	MAGELONA	
5001440101	MAGELONA JAPONICA	5001440101	MAGELONA JAPONICA	
5001440103	MAGELONA PITELKAI	5001440103	MAGELONA PITELKAI	
500149	CHAETOPTERIDAE	500149	CHAETOPTERIDAE	
5001490302	SPIOCHAETOPTERUS COS	5001490302	SPIOCHAETOPTERUS COSTARUM	
5001490401	MESOCHAETOPTERUS TAY	5001490401	MESOCHAETOPTERUS TAYLORI	
500150	CIRRATULIDAE	500150	CIRRATULIDAE	
50015001	CIRRATULUS	50015001	CIRRATULUS	
5001500101	CIRRATULUS CIRRATUS	50015001	CIRRATULUS	

(continued)

TABLE B-2 (continued)

50015003	THARYX	50015003	THARYX	¦*
5001500302	THARYX MULTIFILIS	50015003	THARYX	¦
50015004	CHAETOZONE	50015004	CHAETOZONE	
5001500401	CHAETOZONE SETOSA	5001500401	CHAETOZONE SETOSA	
5001500402	CHAETOZONE GRACILIS	5001500402	CHAETOZONE GRACILIS	
5001580202	ARMANDIA BREVIS	5001580202	ARMANDIA BREVIS	*
50015803	OPHELIA	50015803	OPHELIA	
5001580301	OPHELIA LIMACINA	50015803	OPHELIA	
50015805	THORACOPHELIA	50015805	THORACOPHELIA	
5001580501	THORACOPHELIA MUCRON	50015805	THORACOPHELIA	
500160	CAPITELLIDAE	500160	CAPITELLIDAE	
50016001	CAPITELLA	50016001	CAPITELLA	¦*
5001600101	CAPITELLA CAPITATA	50016001	CAPITELLA	¦
50016003	NOTOMASTUS	50016003	NOTOMASTUS	
5001600302	NOTOMASTUS TENUIS	5001600302	NOTOMASTUS TENUIS	*
5001600303	NOTOMASTUS LINEATUS	5001600303	NOTOMASTUS LINEATUS	
50016004	MEDIOMASTUS	50016004	MEDIOMASTUS	¦*
5001600401	MEDIOMASTUS AMBISETA	50016004	MEDIOMASTUS	¦
5001609999	NAME NOT FOUND	500160	CAPITELLIDAE	
500162	ARENICOLIDAE	500162	ARENICOLIDAE	¦*
50016201	ABARENICOLA	50016201	ABARENICOLA	¦
5001620101	ABARENICOLA CLAPARED	5001620101	ABARENICOLA CLAPAREDI	¦
5001620102	ABARENICOLA PACIFICA	5001620102	ABARENICOLA PACIFICA	¦
5001620104	ABARENICOLA OCEANICA	5001620104	ABARENICOLA OCEANICA	¦
5001620301	BRANCHIOMALDANE VICE	5001620301	BRANCHIOMALDANE VICENTE	¦
500163	MALDANIDAE	500163	MALDANIDAE	¦*
5001630302	MALDANE GLEBIFEX	5001630302	MALDANE GLEBIFEX	¦
5001630802	AXIOTHELLA RUBROCINC	5001630802	AXIOTHELLA RUBROCINCTA	¦
50016311	EUCLYMENE	50016311	EUCLYMENE	¦
5001631101	EUCLYMENE DELINEATA	50016311	EUCLYMENE	¦
5001640102	OWENIA FUSIFORMIS	5001640102	OWENIA FUSIFORMIS	*
5001660202	CISTENIDES GRANULATA	5001660202	CISTENIDES GRANULATA	
500167	AMPHARETIDAE	500167	AMPHARETIDAE	
5001670201	AMPHARETE ARCTICA	5001670201	AMPHARETE ARCTICA	
5001670302	AMPHICTEIS GLABRA	5001670302	AMPHICTEIS GLABRA	
500168	TEREBELLIDAE	500168	TEREBELLIDAE	
5001680201	EUPOLYMNIA HETEROBRA	5001680201	EUPOLYMNIA HETEROBRANCHIA	
50016804	NEOAMPHITRITE	50016804	NEOAMPHITRITE	
5001680601	NICOLEA ZOSTERICOLA	5001680601	NICOLEA ZOSTERICOLA	
5001680701	PISTA CRISTATA	5001680701	PISTA CRISTATA	
5001680702	PISTA FASCIATA	5001680702	PISTA FASCIATA	
5001680710	NAME NOT FOUND	50016807	PISTA	
50016808	POLYCIRRUS	50016808	POLYCIRRUS	
5001680898	NAME NOT FOUND	50016808	POLYCIRRUS	
5001680899	NAME NOT FOUND	50016808	POLYCIRRUS	
50016810	THELEPUS	50016810	THELEPUS	
5001681001	THELEPUS CRISPUS	50016810	THELEPUS	
5001681601	LYSILLA LOVENI	5001681601	LYSILLA LOVENI	

(continued)

TABLE B-2 (continued)

500170	SABELLIDAE	500170	SABELLIDAE	
50017001	CHONE	50017001	CHONE	
5001701301	FABRICIA SABELLA	5001701301	FABRICIA SABELLA	
5001701501	MANAYUNKIA PACIFICA	5001701501	MANAYUNKIA PACIFICA	
5001701502	MANAYUNKIA AESTUARIN	5001701502	MANAYUNKIA AESTUARINA	
50017017	JASMINEIRA	50017017	JASMINEIRA	
500173	SERPULIDAE	500173	SERPULIDAE	
5001730401	SERPULA VERMICULARIS	5001730401	SERPULA VERMICULARIS	
50017305	SPIRORBIS	50017305	SPIRORBIS	
5001730602	DEXIOSPIRA SPIRILLUM	5001730602	DEXIOSPIRA SPIRILLUM	
5002	ARCHIANNELIDA	5002	ARCHIANNELIDA	
500202	PROTODRILIDAE	500202	PROTODRILIDAE	
5002020101	PROTODRILUS FLABELLI	500202	PROTODRILIDAE	
500204	SACCOCIRRIDAE	500204	SACCOCIRRIDAE	
50020401	SACCOCIRRUS	500204	SACCOCIRRIDAE	
5002040101	SACCOCIRRUS EROTICUS	500204	SACCOCIRRIDAE	
50020501	POLYGORDIUS	50020501	POLYGORDIUS	
5004	OLIGOCHAETA	5004	OLIGOCHAETA	
500901	ENCHYTRAEIDAE	500901	ENCHYTRAEIDAE	
500902	TUBIFICIDAE	500902	TUBIFICIDAE	
5012	HIRUDINEA	5012	HIRUDINEA	
5085	MOLLUSCA	5085	MOLLUSCA	
51	GASTROPODA	51	GASTROPODA	
5101	GASTROPODA STREPTONE	5101	GASTROPODA STREPTONEURA	
510205	ACMAEIDAE	510205	ACMAEIDAE	
5102050201	COLLISELLA PELTA	5102050201	COLLISELLA PELTA	
5102050207	COLLISELLA STRIGATEL	5102050207	COLLISELLA STRIGATELLA	
51020503	NOTOACMAEA	51020503	NOTOACMAEA	
5102050301	NOTOACMAEA SCUTUM	5102050301	NOTOACMAEA SCUTUM	
5102050302	NOTOACMAEA PERSONA	5102050302	NOTOACMAEA PERSONA	
51021003	MARGARITES/LIRULARIA	51021003	MARGARITES/LIRULARIA	
5102100308	MARGARITES PUPILLUS	5102100308	MARGARITES PUPILLUS	
5102100310	MARGARITES LIRULATUS	5102100310	MARGARITES LIRULATUS	
5102100312	MARGARITES SUCCINCTU	5102100312	MARGARITES SUCCINCTUS	
51030903	LACUNA	51030903	LACUNA	|*
5103090302	LACUNA VARIEGATA	51030903	LACUNA	|
51031001	LITTORINA	51031001	LITTORINA	
5103100101	LITTORINA SITKANA	5103100101	LITTORINA SITKANA	
5103100104	LITTORINA SCUTULATA	5103100104	LITTORINA SCUTULATA	
51032001	ALVINIA	51032001	ALVINIA	
51032004	BARLEEIA	51032004	BARLEEIA	
5103200401	BARLEEIA HALIOTIPHIL	51032004	BARLEEIA	
5103210101	NAME NOT FOUND	51032101	ASSIMINEA	
5103360101	FARTULUM OCCIDENTALE	5103360101	FARTULUM OCCIDENTALE	
51034602	CERITHIOPSIS	51034602	CERITHIOPSIS	
5103760406	POLINICES LEWISII	5103760406	POLINICES LEWISII	
5105010206	OCENEBRA LURIDA	5105010206	OCENEBRA LURIDA	
51050105	NUCELLA	51050105	NUCELLA	

(continued)

TABLE B-2 (continued)

5105010502	NUCELLA LAMELLOSA	5105010502	NUCELLA LAMELLOSA	
5105010503	NUCELLA EMARGINATA	5105010503	NUCELLA EMARGINATA	
51050108	THAIS	51050108	THAIS	
5105030101	AMPHISSA COLUMBIANA	5105030101	AMPHISSA COLUMBIANA	
5105030202	MITRELLA TUBEROSA	5105030202	MITRELLA TUBEROSA	
5105040201	SEARLESIA DIRA	5105040201	SEARLESIA DIRA	
5105080101	NASSARIUS MENDICUS	5105080101	NASSARIUS MENDICUS	
5107	GASTROPODA EUTHYNEUR	5107	GASTROPODA EUTHYNEURA	
51080101	ODOSTOMIA	51080101	ODOSTOMIA	
51100402	CYLICHNA	51100402	CYLICHNA	
51100601	AGLAJA	51100601	AGLAJA	¦*
5110060101	AGLAJA DIOMEDEUM	51100601	AGLAJA	¦
51101201	HAMINOEA	51101201	HAMINOEA	
5110120101	HAMINOEA VESICULA	5110120101	HAMINOEA VESICULA	
5110120103	HAMINOEA VIRESCENS	5110120103	HAMINOEA VIRESCENS	
51140201	SIPHONARIA	51140201	SIPHONARIA	
5114040101	PHYTIA MYOSOTIS	5114040101	PHYTIA MYOSOTIS	
5123	SACOGLOSSA	5123	SACOGLOSSA	
5124020101	PHYLLAPLYSIA TAYLORI	5124020101	PHYLLAPLYSIA TAYLORI	
5127	NUDIBRANCHIA	5127	NUDIBRANCHIA	
5134080101	MELIBE LEONIS	5134080101	MELIBE LEONIS	
51410101	EUBRANCHUS	51410101	EUBRANCHUS	
514203	AEOLIDIIDAE	514203	AEOLIDIIDAE	
5143	SOLEOLIFERA	5143	SOLEOLIFERA	
53	POLYPLACOPHORA	53	POLYPLACOPHORA	
5303	NEOLORICATA ISCHNOCH	53	POLYPLACOPHORA	
55	BIVALVIA	55	BIVALVIA	
5506060101	GLYCYMERIS SUBOBSOLE	5506060101	GLYCYMERIS SUBOBSOLETA	
550701	MYTILIDAE	550701	MYTILIDAE	
55070101	MYTILUS	55070101	MYTILUS	¦*
5507010101	MYTILUS EDULIS	55070101	MYTILUS	¦
5507010201	CRENELLA DECUSSATA	5507010201	CRENELLA DECUSSATA	
5507010499	NAME NOT FOUND	55070104	MUSCULUS	
5507010603	MODIOLUS RECTUS	5507010603	MODIOLUS RECTUS	
5507011101	ADULA CALIFORNIENSIS	5507011101	ADULA CALIFORNIENSIS	
5507019999	NAME NOT FOUND	550701	MYTILIDAE	
5515010101	PARVILUCINA TENUISCU	5515010101	PARVILUCINA TENUISCULPTA	
5515100102	MYSELLA TUMIDA	5515100102	MYSELLA TUMIDA	*
55152201	CLINOCARDIUM	55152201	CLINOCARDIUM	
5515220102	CLINOCARDIUM NUTTALL	5515220102	CLINOCARDIUM NUTTALLII	*
5515220103	CLINOCARDIUM FUCANUM	5515220103	CLINOCARDIUM FUCANUM	
5515250201	TRESUS CAPAX	5515250201	TRESUS CAPAX	
5515250202	TRESUS NUTTALLII	5515250202	TRESUS NUTTALLII	
5515290101	SILIQUA PATULA	5515290101	SILIQUA PATULA	
55153101	MACOMA	55153101	MACOMA	
5515310114	MACOMA NASUTA	5515310114	MACOMA NASUTA	*
5515310115	MACOMA INQUINATA	5515310115	MACOMA INQUINATA	
5515310116	MACOMA BALTHICA	5515310116	MACOMA BALTHICA	

(continued)

TABLE B-2 (continued)

5515310117	MACOMA SECTA	5515310117	MACOMA SECTA	
55153102	TELLINA	55153102	TELLINA	
5515310203	TELLINA CARPENTERI	5515310203	TELLINA CARPENTERI	
5515310204	TELLINA MODESTA	5515310204	TELLINA MODESTA	
5515350101	SEMELE RUBROPICTA	5515350101	SEMELE RUBROPICTA	
5515470101	TRANSENNELLA TANTILL	5515470101	TRANSENNELLA TANTILLA	*
5515470201	SAXIDOMUS GIGANTEA	5515470201	SAXIDOMUS GIGANTEA	
5515470501	PSEPHIDIA LORDI	5515470501	PSEPHIDIA LORDI	
5515470701	PROTOTHACA STAMINEA	5515470701	PROTOTHACA STAMINEA	*
5515470801	TAPES PHILIPPINARUM	5515470801	TAPES PHILIPPINARUM	
5517010101	CRYPTOMYA CALIFORNIC	5517010101	CRYPTOMYA CALIFORNICA	
5517010201	MYA ARENARIA	5517010201	MYA ARENARIA	*
5517010203	MYA TRUNCATA	5517010203	MYA TRUNCATA	
551706	HIATELLIDAE	551706	HIATELLIDAE	
5517060201	HIATELLA ARCTICA	5517060201	HIATELLA ARCTICA	
5517060401	PANOPEA GENEROSA	5517060401	PANOPEA GENEROSA	
5520050202	LYONSIA CALIFORNICA	5520050202	LYONSIA CALIFORNICA	
59	ARTHROPODA CHELICERA	59	ARTHROPODA CHELICERATA ARACHNIDA	
60	ARTHROPODA PYCNOGONI	60	ARTHROPODA PYCNOGONIDA	
61	ARTHROPODA MANDIBULA	61	ARTHROPODA MANDIBULATA CRUSTACEA	
6110	OSTRACODA	6110	OSTRACODA	
61100	NAME NOT FOUND	6110	OSTRACODA	
6111	OSTRACODA MYODOCOPA	6111	OSTRACODA MYODOCOPA	
6117	COPEPODA	6117	COPEPODA	
6118	COPEPODA CALANOIDA	6118	COPEPODA CALANOIDA	
6119	COPEPODA HARPACTICOI	6119	COPEPODA HARPACTICOIDA	
6122	COPEPODA MONSTRILLOI	6122	COPEPODA MONSTRILLOIDA	
6130	CIRRIPEDIA	6130	CIRRIPEDIA	
6134010101	CHTHAMALUS DALLI	6134010101	CHTHAMALUS DALLI	
61340201	BALANUS	61340201	BALANUS	¦*
6134020102	BALANUS BALANUS	6134020102	BALANUS BALANUS	¦
6134020103	BALANUS CARIOSUS	6134020103	BALANUS CARIOSUS	¦
6134020104	BALANUS CRENATUS	6134020104	BALANUS CRENATUS	¦
6134020107	BALANUS GLANDULA	6134020107	BALANUS GLANDULA	¦
61450101	NEBALIA	61450101	NEBALIA	
6145010102	NEBALIA PUGETTENSIS	61450101	NEBALIA	
6151	PERACARIDA MYSIDACEA	6151	PERACARIDA MYSIDACEA	
6153010301	ARCHAEOMYSIS GREBNIT	6153010301	ARCHAEOMYSIS GREBNITZKII	*
6153010901	HOLMESIELLA ANOMALA	6153010901	HOLMESIELLA ANOMALA	
6153011505	NEOMYSIS MERCEDIS	6153011505	NEOMYSIS MERCEDIS	
6154	PERACARIDA CUMACEA	6154	PERACARIDA CUMACEA	
615401	LAMPROPIDAE	615401	LAMPROPIDAE	
61540101	LAMPROPS	615401	LAMPROPIDAE	
6154010104	LAMPROPS CARINATA	615401	LAMPROPIDAE	
61540402	EUDORELLA	61540402	EUDORELLA	
6154040203	EUDORELLA TRIDENTATA	61540402	EUDORELLA	
61540501	DIASTYLIS	61540501	DIASTYLIS	
61540502	DIASTYLOPSIS	61540502	DIASTYLOPSIS	

(continued)

TABLE B-2 (continued)

6154050202	DIASTYLOPSIS TENUIS	61540502	DIASTYLOPSIS	
6154050299	NAME NOT FOUND	61540502	DIASTYLOPSIS	
61540505	COLUROSTYLIS	61540505	COLUROSTYLIS	
61540801	CUMELLA	61540801	CUMELLA	
6154080102	CUMELLA VULGARIS	61540801	CUMELLA	
61540903	LEPTOCUMA/PSEUDOLEPT	61540903	LEPTOCUMA/PSEUDOLEPTOCUMA	
6155	PERACARIDA TANAIDACE	6155	PERACARIDA TANAIDACEA	
6157	PERACARIDA TANAIDACE	6157	PERACARIDA TANAIDACEA DIKONOPHOR	
6157010301	ANATANAIS NORMANI	6157010301	ANATANAIS NORMANI	
6157010401	PANCOLUS CALIFORNIEN	6157010401	PANCOLUS CALIFORNIENSIS	
61570201	LEPTOCHELIA (TANAI	61570201	LEPTOCHELIA (TANAIDACEA)	¦*
6157020101	LEPTOCHELIA SAVIGNYI	6157020101	LEPTOCHELIA SAVIGNYI	¦
6157020103	LEPTOCHELIA DUBIA	6157020103	LEPTOCHELIA DUBIA	¦
6157020199	NAME NOT FOUND	61570201	LEPTOCHELIA (TANAIDACEA)	¦
6161	PERACARIDA ISOPODA F	6161	PERACARIDA ISOPODA FLABELLIFERA	
6161010101	CIROLANA KINCAIDI	6161010101	CIROLANA KINCAIDI	*
6161010102	CIROLANA HARFORDI	6161010102	CIROLANA HARFORDI	
6161010199	NAME NOT FOUND	61610101	CIROLANA	
6161020199	NAME NOT FOUND	61610201	TECTICEPS	
61610203	GNORIMOSPHAEROMA	61610203	GNORIMOSPHAEROMA	¦*
6161020301	GNORIMOSPHAEROMA ORE	61610203	GNORIMOSPHAEROMA	¦
61610204	EXOSPHAEROMA	61610204	EXOSPHAEROMA	
6161020401	EXOSPHAEROMA AMPLICA	6161020401	EXOSPHAEROMA AMPLICAUDA	
6161020402	EXOSPHAEROMA MEDIA	6161020402	EXOSPHAEROMA MEDIA	*
6161020501	DYNAMENELLA SHEARERI	6161020501	DYNAMENELLA SHEARERI	
61610501	LIMNORIA	61610501	LIMNORIA	
6161050101	LIMNORIA LIGNORUM	61610501	LIMNORIA	
6162	PERACARIDA ISOPODA V	6162	PERACARIDA ISOPODA VALVIFERA	
61620202	SYNIDOTEA	61620202	SYNIDOTEA	
6162020201	SYNIDOTEA BICUSPIDA	6162020201	SYNIDOTEA BICUSPIDA	
6162020205	SYNIDOTEA NODULOSA	6162020205	SYNIDOTEA NODULOSA	
6162020210	SYNIDOTEA ANGULATA	6162020210	SYNIDOTEA ANGULATA	
61620203	IDOTEA	61620203	IDOTEA	
6162020301	IDOTEA RESECATA	6162020301	IDOTEA RESECATA	
6162020302	IDOTEA WOSNESENSKII	6162020302	IDOTEA WOSNESENSKII	
6162020305	IDOTEA OCHOTENSIS	6162020305	IDOTEA OCHOTENSIS	
6162020307	IDOTEA ACULEATA	6162020307	IDOTEA ACULEATA	
6162020313	IDOTEA MONTEREYENSIS	6162020313	IDOTEA MONTEREYENSIS	
6163020101	IANIROPSIS KINCAIDI	6163020101	IANIROPSIS KINCAIDI	
6163069999	NAME NOT FOUND	616306	JANIRIDAE	
616504	BOPYRIDAE	616504	BOPYRIDAE	
6165040701	PHYLLODURUS ABDOMINA	616504	BOPYRIDAE	
6166020101	ARMADILLONISCUS TUBE	6166020101	ARMADILLONISCUS TUBERCULATUS	
6166030101	DETONELLA PAPILLICOR	6166030101	DETONELLA PAPILLICORNIS	
6168	PERACARIDA AMPHIPODA	6168	PERACARIDA AMPHIPODA	
6169	PERACARIDA AMPHIPODA	6169	GAMMARID AMPHIPOD	
6169020111	AMPELISCA AGASSIZI	6169	GAMMARID AMPHIPOD	
6169020114	AMPELISCA PUGETICA	6169	GAMMARID AMPHIPOD	

(continued)

TABLE B-2 (continued)

6169020197	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169030202	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
61690401	AMPHITHOE	6169	GAMMARID AMPHIPOD	
6169040116	AMPHITHOE VALIDA	6169	GAMMARID AMPHIPOD	
6169040195	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169060202	AOROIDES COLUMBIAE	6169	GAMMARID AMPHIPOD	
6169090101	ATYLUS TRIDENS	6169	GAMMARID AMPHIPOD	
6169090105	ATYLUS COLLINGI	6169	GAMMARID AMPHIPOD	
6169090108	ATYLUS LEVIDENSUS	6169	GAMMARID AMPHIPOD	
6169120201	CALLIOPIUS LAEVIUSCU	6169	GAMMARID AMPHIPOD	
6169121001	CALLIOPIELLA PRATTI	6169	GAMMARID AMPHIPOD	
616915	COROPHIIDAE	6169	GAMMARID AMPHIPOD	
61691502	COROPHIUM	61691502	COROPHIUM	¦*
6169150201	COROPHIUM ACHERUSICU	61691502	COROPHIUM	¦
6169150203	COROPHIUM CRASSICORN	61691502	COROPHIUM	¦
6169150208	COROPHIUM BREVIS	61691502	COROPHIUM	¦
6169150209	COROPHIUM SALMONIS	61691502	COROPHIUM	¦
6169150211	COROPHIUM INSIDIOSUM	61691502	COROPHIUM	¦
6169200101	ACCEDOMOERA VAGOR	6169	GAMMARID AMPHIPOD	
61692010	PARAMOERA	61692010	PARAMOERA	¦*
6169201003	PARAMOERA MOHRI	61692010	PARAMOERA	¦
6169201097	NAME NOT FOUND	61692010	PARAMOERA	¦
6169201098	NAME NOT FOUND	61692010	PARAMOERA	¦
61692012	PONTOGENEIA	6169	GAMMARID AMPHIPOD	
6169201208	PONTOGENEIA ROSTRATA	6169	GAMMARID AMPHIPOD	
6169201297	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169201299	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
61692101	ANISOGAMMARUS	6169	GAMMARID AMPHIPOD	
6169210106	ANISOGAMMARUS PUGETT	6169	GAMMARID AMPHIPOD	
6169210109	ANISOGAMMARUS CONFER	6169	GAMMARID AMPHIPOD	
61692103	ELASMOPUS	6169	GAMMARID AMPHIPOD	
6169210805	MAERA DUBIA	6169	GAMMARID AMPHIPOD	
61692110	MELITA (AMPHIPODA	6169	GAMMARID AMPHIPOD	
6169211003	MELITA DENTATA	6169	GAMMARID AMPHIPOD	
6169211008	MELITA DESDICHADA	6169	GAMMARID AMPHIPOD	
6169211099	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
616922	HAUSTORIIDAE	6169	GAMMARID AMPHIPOD	
61692201	EOHAUSTORIUS	61692201	EOHAUSTORIUS	¦*
6169220101	EOHAUSTORIUS WASHING	61692201	EOHAUSTORIUS	¦
6169220199	NAME NOT FOUND	61692201	EOHAUSTORIUS	¦
6169240105	ALLORCHESTES ANGUSTU	6169	GAMMARID AMPHIPOD	
61692402	HYALE	6169	GAMMARID AMPHIPOD	
6169240201	HYALE RUBRA	6169	GAMMARID AMPHIPOD	
6169240204	HYALE PLUMULOSA	6169	GAMMARID AMPHIPOD	
6169240207	HYALE GRANDICORNIS	6169	GAMMARID AMPHIPOD	
6169240401	PARALLORCHESTES OCHO	6169	GAMMARID AMPHIPOD	
61692602	PHOTIS	6169	GAMMARID AMPHIPOD	
6169260201	PHOTIS BREVIPES	6169	GAMMARID AMPHIPOD	

(continued)

TABLE B-2 (continued)

61692603	PROTOMEDEIA	6169	GAMMARID AMPHIPOD	
6169260398	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169260399	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
61692604	GAMMAROPSIS	6169	GAMMARID AMPHIPOD	
6169260401	GAMMAROPSIS THOMPSON	6169	GAMMARID AMPHIPOD	
61692702	ISCHYROCERUS	6169	GAMMARID AMPHIPOD	
6169270202	ISCHYROCERUS ANGUIPE	6169	GAMMARID AMPHIPOD	
616934	LYSIANASSIDAE	6169	GAMMARID AMPHIPOD	
61693429	ORCHOMENE	6169	GAMMARID AMPHIPOD	
6169345201	ORCHOMENELLA MINUTA	6169	GAMMARID AMPHIPOD	
6169371402	SYNCHELIDIUM SHOEMAK	6169	GAMMARID AMPHIPOD	
6169371403	SYNCHELIDIUM RECTIPA	6169	GAMMARID AMPHIPOD	
6169371498	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169371499	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
616942	PHOXOCEPHALIDAE	616942	PHOXOCEPHALIDAE	¦*
61694209	PARAPHOXUS	616942	PHOXOCEPHALIDAE	¦
6169420901	PARAPHOXUS TRIDENTAT	616942	PHOXOCEPHALIDAE	¦
6169420921	PARAPHOXUS MILLERI	616942	PHOXOCEPHALIDAE	¦
6169420927	PARAPHOXUS EPISTOMUS	616942	PHOXOCEPHALIDAE	¦
6169420928	PARAPHOXUS SPINOSUS	616942	PHOXOCEPHALIDAE	¦
6169420930	PARAPHOXUS SIMILIS	616942	PHOXOCEPHALIDAE	¦
6169420987	NAME NOT FOUND	616942	PHOXOCEPHALIDAE	¦
6169420988	NAME NOT FOUND	616942	PHOXOCEPHALIDAE	¦
6169420989	NAME NOT FOUND	616942	PHOXOCEPHALIDAE	¦
6169420999	NAME NOT FOUND	616942	PHOXOCEPHALIDAE	¦
6169440401	PODOCERUS CRISTATUS	6169	GAMMARID AMPHIPOD	
6169500502	TIRON BIOCULATA	6169	GAMMARID AMPHIPOD	
616951	TALITRIDAE	6169	GAMMARID AMPHIPOD	
61695101	ORCHESTIA	6169	GAMMARID AMPHIPOD	
6169510106	ORCHESTIA TRASKIANA	6169	GAMMARID AMPHIPOD	
6169510108	ORCHESTIA GEORGIANA	6169	GAMMARID AMPHIPOD	
6169510199	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
61695104	ORCHESTOIDEA	6169	GAMMARID AMPHIPOD	
6169510401	ORCHESTOIDEA PUGETTE	6169	GAMMARID AMPHIPOD	
6169510499	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6170011005	PARATHEMISTO ABYSSOR	6170011005	PARATHEMISTO ABYSSORUM HOM.1	
6171	PERACARIDA AMPHIPODA	6171	PERACARIDA AMPHIPODA CAPRELLIDEA	
6171010401	METACAPRELLA KENNERL	6171010401	METACAPRELLA KENNERLYI	
6171010602	TRITELLA PILIMANA	6171010602	TRITELLA PILIMANA	
61710107	CAPRELLA (AMPHIPO	61710107	CAPRELLA (AMPHIPODA)	
6171010708	CAPRELLA IRREGULARIS	6171010708	CAPRELLA IRREGULARIS	
6171010710	CAPRELLA LAEVIUSCULA	6171010710	CAPRELLA LAEVIUSCULA	
6175	EUCARIDA DECAPODA(AR	6175	EUCARIDA DECAPODA(ARTHROPODA)	
6179	EUCARIDA DECAPODA PL	6179	EUCARIDA DECAPODA PLEOCYEMATA CA	
6179140201	BETAEUS HARRIMANI	6179140201	BETAEUS HARRIMANI	
617916	HIPPOLYTIDAE	617916	HIPPOLYTIDAE	
61791605	HEPTACARPUS	61791605	HEPTACARPUS	
6179160508	HEPTACARPUS SITCHENS	6179160508	HEPTACARPUS SITCHENSIS	

(continued)

TABLE B-2 (continued)

6179160510	HEPTACARPUS BREVIROS	6179160510	HEPTACARPUS BREVIROSTRIS
6179160513	HEPTACARPUS TENUISSI	6179160513	HEPTACARPUS TENUISSIMUS
61791801	PANDALUS	61791801	PANDALUS
61792201	CRANGON	61792201	CRANGON
6179220101	CRANGON NIGRICAUDA	6179220101	CRANGON NIGRICAUDA
6179220107	CRANGON FRANCISCORUM	6179220107	CRANGON FRANCISCORUM
6179220111	CRANGON MUNITA	6179220111	CRANGON MUNITA
6179220115	CRANGON MUNITELLA	6179220115	CRANGON MUNITELLA
6179220202	SCLEROCRANGON ALATA	6179220202	SCLEROCRANGON ALATA
618304	CALLIANASSIDAE	618304	CALLIANASSIDAE
6183040101	UPOGEBIA PUGETTENSIS	6183040101	UPOGEBIA PUGETTENSIS
61830402	CALLIANASSA	61830402	CALLIANASSA
6183040204	CALLIANASSA CALIFORN	61830402	CALLIANASSA
618306	PAGURIDAE	618306	PAGURIDAE
61830602	PAGURUS (DECAPODA)	61830602	PAGURUS (DECAPODA)
6183060211	PAGURUS GRANOSIMANUS	6183060211	PAGURUS GRANOSIMANUS
6183060213	PAGURUS HIRSUTIUSCUL	6183060213	PAGURUS HIRSUTIUSCULUS
6184	EUCARIDA DECAPODA PL	6184	EUCARIDA DECAPODA PLEOCYEMATA BR
618701	MAJIDAE	618701	MAJIDAE
6187010101	OREGONIA GRACILIS	6187010101	OREGONIA GRACILIS
61870105	PUGETTIA (DECAPODA	61870105	PUGETTIA (DECAPODA)
6187010503	PUGETTIA GRACILIS	61870105	PUGETTIA (DECAPODA)
6188020101	TELMESSUS CHEIRAGONU	6188020101	TELMESSUS CHEIRAGONUS
61880301	CANCER	61880301	CANCER
6188030101	CANCER PRODUCTUS	6188030101	CANCER PRODUCTUS
6188030104	CANCER MAGISTER	6188030104	CANCER MAGISTER
6188030106	CANCER OREGONENSIS	6188030106	CANCER OREGONENSIS
6189020301	FABIA SUBQUADRATA	6189020301	FABIA SUBQUADRATA
618906	PINNOTHERIDAE	618906	PINNOTHERIDAE
61890604	PINNIXA	61890604	PINNIXA
6189060401	PINNIXA FABA	6189060401	PINNIXA FABA
6189060402	PINNIXA LITTORALIS	6189060402	PINNIXA LITTORALIS
6189060403	PINNIXA OCCIDENTALIS	6189060403	PINNIXA OCCIDENTALIS
61890701	HEMIGRAPSUS	61890701	HEMIGRAPSUS
6189070101	HEMIGRAPSUS NUDUS	6189070101	HEMIGRAPSUS NUDUS
6189070102	HEMIGRAPSUS OREGONEN	6189070102	HEMIGRAPSUS OREGONENSIS
6189070301	SCLEROPLAX GRANULATA	6189070301	SCLEROPLAX GRANULATA
62	INSECTA I	62	INSECTA I
6209010101	ANURIDA MARITIMA	6209010101	ANURIDA MARITIMA
6223	ODONATA	6223	ODONATA
6282	HOMOPTERA	6282	HOMOPTERA
630503	CARABIDAE	630503	CARABIDAE
6310	STAPHYLINOIDEA	6310	STAPHYLINOIDEA
631001	STAPHYLINIDAE	631001	STAPHYLINIDAE
65	INSECTA IV	65	INSECTA IV
6501	DIPTERA	6501	DIPTERA
650508	CHIRONOMIDAE	650508	CHIRONOMIDAE
651802	DOLICHOPODIDAE	651802	DOLICHOPODIDAE

(continued)

TABLE B-2 (continued)

654102	TACHINIDAE	654102	TACHINIDAE	
65730701	CAMPONOTUS	65730701	CAMPONOTUS	
66	ARTHROPODA MANDIBULA	66	ARTHROPODA MANDIBULATA CHILOPODA	
72	SIPUNCULIDA	72	SIPUNCULIDA	
7200020104	GOLFINGIA PUGETTENSI	7200020104	GOLFINGIA PUGETTENSIS	
7400010101	PRIAPULUS CAUDATUS	7400010101	PRIAPULUS CAUDATUS	
77	PHORONIDA	77	PHORONIDA	
770001	PHORONIDAE	770001	PHORONIDAE	
7700010102	PHORONOPSIS HARMERI	77000101	PHORONOPSIS	¦*
7700010199	NAME NOT FOUND	77000101	PHORONOPSIS	¦
77000102	PHORONIS	77000102	PHORONIS	
7700010201	PHORONIS VANCOUVEREN	77000102	PHORONIS	
78	ECTOPROCTA	78	ECTOPROCTA	
8117030409	LEPTASTERIAS HEXACTI	8117030409	LEPTASTERIAS HEXACTIS	
8120	OPHIUROIDEA	8120	OPHIUROIDEA	
812701	OPHIURIDAE	812701	OPHIURIDAE	
8129	OPHIUROIDEA OPHIURID	8129	OPHIUROIDEA OPHIURIDA GNATHOPHIU	
812903	AMPHIURIDAE	812903	AMPHIURIDAE	
8129030202	AMPHIPHOLIS SQUAMATA	81290302	AMPHIPHOLIS	
8129030299	NAME NOT FOUND	81290302	AMPHIPHOLIS	
8129030303	DIAMPHIODIA PERIERCT	8129030303	DIAMPHIODIA PERIERCTA	
81290306	OPHIOPHRAGMUS	81290306	OPHIOPHRAGMUS	
8129030601	OPHIOPHRAGMUS URTICA	81290306	OPHIOPHRAGMUS	
8136	ECHINOIDEA	8136	ECHINOIDEA	
8155010101	DENDRASTER EXCENTRIC	8155010101	DENDRASTER EXCENTRICUS	
8170	HOLOTHUROIDEA	8170	HOLOTHUROIDEA	
81780102	LEPTOSYNAPTA	81780102	LEPTOSYNAPTA	¦*
8178010203	LEPTOSYNAPTA CLARKI	81780102	LEPTOSYNAPTA	¦
8406010505	STYELA GIBBSII	8406010505	STYELA GIBBSII	
8717	OSTEICHTHYES	8717	OSTEICHTHYES	
88	GNATHOSTOMATA II	88	GNATHOSTOMATA II	
8842130206	PHOLIS ORNATA (SADDL	8842130206	PHOLIS ORNATA (SADDLEBACK GUNNEL	
8847010101	CLEVELANDIA IOS	8847010101	CLEVELANDIA IOS	
99990001	NAME NOT FOUND	ER		
999999	NAME NOT FOUND	ER		
ABIOTIC	NAME NOT FOUND	ABIOTIC	NONE OF THE ABOVE TAXA	*

TABLE B-3. TAXONOMIC DICTIONARY FOR SUBTIDAL SUBSTRATES

00	NAME NOT FOUND	ER	
07	BACILLARIOPHYTA	07	BACILLARIOPHYTA
0701	BACILLARIOPHYCEAE	07	BACILLARIOPHYTA
0703	BACILLARIOPHYCEAE PE	07	BACILLARIOPHYTA
070301	DIATOMACEAE	07	BACILLARIOPHYTA
07030501	NAVICULA	07	BACILLARIOPHYTA
07030515	AMPHIPLEURA	07	BACILLARIOPHYTA
08050102	ULOTHRIX	08050102	ULOTHRIX
08050201	MONOSTROMA	08050201	MONOSTROMA
0805020102	MONOSTROMA OXYSPERMU	08050201	MONOSTROMA
0805020105	MONOSTROMA FUSCUM	08050201	MONOSTROMA
0805020106	MONOSTROMA GREVILLEI	08050201	MONOSTROMA
08050303	ENTEROMORPHA	08050303	ENTEROMORPHA
0805030306	ENTEROMORPHA LINZA	0805030306	ENTEROMORPHA LINZA
0805030317	ENTEROMORPHA INTESTI	0805030317	ENTEROMORPHA INTESTINALIS
08050305	ULVA (CHLOROPHYCE	08050305	ULVA (CHLOROPHYCEAE)
0805030501	ULVA FENESTRATA	08050305	ULVA (CHLOROPHYCEAE)
0805030503	ULVA LACTUCA	08050305	ULVA (CHLOROPHYCEAE)
0805030505	ULVA LOBATA	08050305	ULVA (CHLOROPHYCEAE)
0806011599	NAME NOT FOUND	08060115	ENTOCLADIA
08070102	SPONGOMORPHA	08070102	SPONGOMORPHA
0807010202	SPONGOMORPHA COALITA	0807010202	SPONGOMORPHA COALITA
0807010205	SPONGOMORPHA MERTENS	0807010205	SPONGOMORPHA MERTENSII
0807010207	SPONGOMORPHA SPINESC	0807010207	SPONGOMORPHA SPINESCENS
08080101	CHAETOMORPHA	08080101	CHAETOMORPHA
0808010199	NAME NOT FOUND	08080101	CHAETOMORPHA
08080102	CLADOPHORA	08080102	CLADOPHORA
0808010299	NAME NOT FOUND	08080102	CLADOPHORA
0808010302	RHIZOCLONIUM RIPARIU	0808010302	RHIZOCLONIUM RIPARIUM
0809010101	DERBESIA MARINA	0809010101	DERBESIA MARINA
08090201	BRYOPSIS	08090201	BRYOPSIS
0809020103	BRYOPSIS CORTICULANS	08090201	BRYOPSIS
0809030201	HALICYSTIS OVALIS	0809030201	HALICYSTIS OVALIS
1501	PHAEOPHYCEAE	1501	PHAEOPHYCEAE
150201	ECTOCARPACEAE	150201	ECTOCARPACEAE
15020103	ECTOCARPUS	15020103	ECTOCARPUS
1502010404	GIFFORDIA OVATA	1502010404	GIFFORDIA OVATA
15020106	PYLAIELLA	15020106	PYLAIELLA
15020109	FELDMANNIA	15020109	FELDMANNIA
150202	RALFSIACEAE	150202	RALFSIACEAE
15020203	RALFSIA	150202	RALFSIACEAE
1502020302	RALFSIA FUNGIFORMIS	150202	RALFSIACEAE
1502020303	RALFSIA PACIFICA	150202	RALFSIACEAE
1502020399	NAME NOT FOUND	150202	RALFSIACEAE
1502061001	HAPLOGLOIA ANDERSONI	1502061001	HAPLOGLOIA ANDERSONII

(continued)

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* Starred species or groups are important taxa used for clustering.

+ Plus sign denotes species or groups used only in analyses based on 132 taxa.

TABLE B-3 (continued)

1502061202	ANALIPUS JAPONICUS	1502061202	ANALIPUS JAPONICUS	
1503010201	STICTYOSIPHON TORTIL	1503010201	STICTYOSIPHON TORTILIS	
15040102	SPHACELARIA	15040102	SPHACELARIA	
1504010204	SPHACELARIA NORRISII	15040102	SPHACELARIA	
1507010601	SYRINGODERMA ABYSSIC	15070106	SYRINGODERMA	
1507010699	NAME NOT FOUND	15070106	SYRINGODERMA	
1508	PHAEOPHYCEAE LAMINAR	1508	PHAEOPHYCEAE LAMINARIALES	
150802	LAMINARIACEAE	150802	LAMINARIACEAE	
15080201	LAMINARIA	15080201	LAMINARIA	
1508020102	LAMINARIA GROENLANDI	1508020102	LAMINARIA GROENLANDICA	
1508020104	LAMINARIA SACCHARINA	1508020104	LAMINARIA SACCHARINA	*
1508020105	LAMINARIA SETCHELLII	1508020105	LAMINARIA SETCHELLII	
1508020107	LAMINARIA FARLOWII	1508020107	LAMINARIA FARLOWII	
15080203	COILODESME	15080203	COILODESME	
1508020401	AGARUM CRIBROSUM	1508020401	AGARUM CRIBROSUM	
1508020501	COSTARIA COSTATA	1508020501	COSTARIA COSTATA	
1508020601	CYMATHERE TRIPLICATA	1508020601	CYMATHERE TRIPLICATA	
1508020701	HEDOPHYLLUM SESSILE	1508020701	HEDOPHYLLUM SESSILE	
15080209	PLEUROPHYCUS	15080209	PLEUROPHYCUS	
1508020901	PLEUROPHYCUS GARDNER	15080209	PLEUROPHYCUS	
1508021101	PHAEOSTROPHION IRREG	1508021101	PHAEOSTROPHION IRREGULARE	
1508030301	NEREOCYSTIS LUETKEAN	1508030301	NEREOCYSTIS LUETKEANA	
15080401	ALARIA	15080401	ALARIA	¦*
1508040103	ALARIA MARGINATA	1508040103	ALARIA MARGINATA	¦
1508040108	ALARIA TENUIFOLIA	1508040108	ALARIA TENUIFOLIA	¦
1508040201	PTERYGOPHORA CALIFOR	1508040201	PTERYGOPHORA CALIFORNICA	
1508040301	EGREGIA MENZIESII	1508040301	EGREGIA MENZIESII	
15090201	DESMARESTIA	15090201	DESMARESTIA	
1509020101	DESMARESTIA ACULEATA	1509020101	DESMARESTIA ACULEATA	
1509020102	DESMARESTIA LIGULATA	1509020102	DESMARESTIA LIGULATA	*
1509020103	DESMARESTIA VIRIDIS	1509020103	DESMARESTIA VIRIDIS	
1510010202	FUCUS DISTICHUS	1510010202	FUCUS DISTICHUS	
1510030201	CYSTOSEIRA GEMINATA	1510030201	CYSTOSEIRA GEMINATA	
1512010301	SCYTOSIPHON LOMENTAR	1512010301	SCYTOSIPHON LOMENTARIA	
16	RHODOPHYTA	16	RHODOPHYTA	
1601	RHODOPHYCEAE	16	RHODOPHYTA	
1604010101	GONIOTRICHUM ALSIDII	16040101	GONIOTRICHUM	
1604010199	NAME NOT FOUND	16040101	GONIOTRICHUM	
1605010501	SMITHORA NAIADUM	1605010501	SMITHORA NAIADUM	
1605020199	NAME NOT FOUND	16050201	BANGIA	
16050202	PORPHYRA	16050202	PORPHYRA	
1605020209	PORPHYRA PERFORATA	16050202	PORPHYRA	
1605020229	PORPHYRA OCCIDENTALI	16050202	PORPHYRA	
16070101	ACROCHAETIUM	16070101	ACROCHAETIUM	
1607010107	ACROCHAETIUM PACIFIC	16070101	ACROCHAETIUM	
16070104	RHODOCHORTON	16070104	RHODOCHORTON	
1607010402	RHODOCHORTON PURPURE	16070104	RHODOCHORTON	
16070602	BONNEMAISONIA	16070602	BONNEMAISONIA	

(continued)

TABLE B-3 (continued)

1607060299	NAME NOT FOUND	16070602	BONNEMAISONIA	
1607070101	GELIDIUM CRINALE	1607070101	GELIDIUM CRINALE	
160801	CRUORIACEAE	160801	CRUORIACEAE	
1608010199	NAME NOT FOUND	16080101	CRUORIA	
1608010299	NAME NOT FOUND	16080102	CRUORIOPSIS	
1608010302	PETROCELIS MIDDENDOR	1608010302	PETROCELIS MIDDENDORFFII	
16080201	NEOAGARDHIELLA	16080201	NEOAGARDHIELLA	¦+
1608020101	NEOAGARDHIELLA BAILE	16080201	NEOAGARDHIELLA	¦
1608020201	OPUNTIELLA CALIFORNI	1608020201	OPUNTIELLA CALIFORNICA	
1608020301	SARCODIOTHECA FURCAT	1608020301	SARCODIOTHECA FURCATA	+
16080501	PLOCAMIUM (RHODOPH	16080501	PLOCAMIUM (RHODOPHYTA)	
1608050101	PLOCAMIUM TENUE	1608050101	PLOCAMIUM TENUE	
1608050102	PLOCAMIUM COCCINEUM	1608050102	PLOCAMIUM COCCINEUM	+
1608050103	PLOCAMIUM PACIFICUM	1608050103	PLOCAMIUM PACIFICUM	
1608050104	PLOCAMIUM VIOLACIUM	1608050104	PLOCAMIUM VIOLACIUM	
1608050195	NAME NOT FOUND	16080501	PLOCAMIUM (RHODOPHYTA)	
16080502	RHODOPHYLLIS/PLOCAMI	16080502	RHODOPHYLLIS/PLOCAMIOCOLAX	
16080701	GRACILARIA	16080701	GRACILARIA	
1608070102	GRACILARIA VERRUCOSA	16080701	GRACILARIA	
16080702	GRACILARIOPSIS	16080702	GRACILARIOPSIS	¦+
1608070201	GRACILARIOPSIS SJOES	16080702	GRACILARIOPSIS	¦
160809	PHYLLOPHORACEAE	160809	PHYLLOPHORACEAE	
16080901	AHNFELTIA	16080901	AHNFELTIA	
1608090101	AHNFELTIA PLICATA	1608090101	AHNFELTIA PLICATA	
1608090102	AHNFELTIA GIGARTINOI	1608090102	AHNFELTIA GIGARTINOIDES	
1608090301	STENOGRAMME INTERRUP	1608090301	STENOGRAMME INTERRUPTA	
16080904	GYMNOGONGRUS	16080904	GYMNOGONGRUS	
1608090402	GYMNOGONGRUS LEPTOPH	16080904	GYMNOGONGRUS	
160810	GIGARTINACEAE	160810	GIGARTINACEAE	
16081002	GIGARTINA	16081002	GIGARTINA	
1608100203	GIGARTINA PAPILLATA	1608100203	GIGARTINA PAPILLATA	
1608100204	GIGARTINA AGARDHII	1608100204	GIGARTINA AGARDHII	
1608100209	GIGARTINA HARVEYANA	1608100209	GIGARTINA HARVEYANA	
16081003	IRIDAEA	16081003	IRIDAEA	
1608100301	IRIDAEA CORDATA	1608100301	IRIDAEA CORDATA	
1608100304	IRIDAEA HETEROCARPA	1608100304	IRIDAEA HETEROCARPA	
1608100305	IRIDAEA LINEARE	1608100305	IRIDAEA LINEARE	
16081004	RHODOGLOSSUM	16081004	RHODOGLOSSUM	
1608100401	RHODOGLOSSUM AFFINE	1608100401	RHODOGLOSSUM AFFINE	
1608100402	RHODOGLOSSUM CALIFOR	1608100402	RHODOGLOSSUM CALIFORNICUM	
1608100404	RHODOGLOSSUM ROSEUM	1608100404	RHODOGLOSSUM ROSEUM	
16081201	SCHIZYMENIA	16081201	SCHIZYMENIA	
1608120102	SCHIZYMENIA EPIPHYTI	16081201	SCHIZYMENIA	
1609	RHODOPHYCEAE FLORIDE	1609	RHODOPHYCEAE FLORIDEOPHYCIDAE CR	
160901	SQUAMARIACEAE	160901	SQUAMARIACEAE	
16090103	PEYSSONELIA	16090103	PEYSSONELIA	
1609010301	PEYSSONELIA PACIFICA	16090103	PEYSSONELIA	
1609020101	DILSEA CALIFORNICA	1609020101	DILSEA CALIFORNICA	

(continued)

TABLE B-3 (continued)

1609020202	PIKEA ROBUSTA	16090202	PIKEA	
1609020299	NAME NOT FOUND	16090202	PIKEA	
16090204	FARLOWIA	16090204	FARLOWIA	
1609020701	THURETELLOPSIS PEGGI	1609020701	THURETELLOPSIS PEGGIANA	
1609050101	ENDOCLADIA MURICATA	1609050101	ENDOCLADIA MURICATA	
16090601	HILDENBRANDIA (ALG	16090601	HILDENBRANDIA (ALGAE)	
1609060101	HILDENBRANDIA OCCIDE	16090601	HILDENBRANDIA (ALGAE)	
160907	CORALLINACEAE	160907	CORALLINACEAE	
16090703	CORALLINA	16090703	CORALLINA	
16090707	LITHOTHAMNION	16090707	LITHOTHAMNION	
1609070701	LITHOTHAMNION CALIFO	16090707	LITHOTHAMNION	
16090709	MESOPHYLLUM	16090709	MESOPHYLLUM	
1609070902	MESOPHYLLUM CONCHATU	16090709	MESOPHYLLUM	
1609071303	CLATHROMORPHUM PARCU	1609071303	CLATHROMORPHUM PARCUM	
16090715	BOSSIELLA	16090715	BOSSIELLA	
1609071504	BOSSIELLA ORBIGNIANA	16090715	BOSSIELLA	
1609071505	BOSSIELLA PLUMOSA	16090715	BOSSIELLA	
1609071701	CALLIARTHRON TUBERCU	1609071701	CALLIARTHRON TUBERCULOSUM	
160909	CRYPTONEMIACEAE	160909	CRYPTONEMIACEAE	
16090901	CRYPTONEMIA	16090901	CRYPTONEMIA	|+
1609090101	CRYPTONEMIA OBOVATA	1609090101	CRYPTONEMIA OBOVATA	|
1609090102	CRYPTONEMIA OVALIFOL	1609090102	CRYPTONEMIA OVALIFOLIA	|
1609090103	CRYPTONEMIA BOREALIS	1609090103	CRYPTONEMIA BOREALIS	|
16090902	GRATELOUPIA	16090902	GRATELOUPIA	
1609090201	GRATELOUPIA DORYPHOR	16090902	GRATELOUPIA	
16090904	PRIONITIS	16090904	PRIONITIS	
1609090401	PRIONITIS LANCEOLATA	1609090401	PRIONITIS LANCEOLATA	
1609090402	PRIONITIS LYALLII	1609090402	PRIONITIS LYALLII	
16090905	HALYMENIA	16090905	HALYMENIA	
1609090501	HALYMENIA COCCINEA	1609090501	HALYMENIA COCCINEA	
1609090502	HALYMENIA CALIFORNIC	1609090502	HALYMENIA CALIFORNICA	
1609090503	HALYMENIA SCHIZYMENI	1609090503	HALYMENIA SCHIZYMENIOIDES	
1609090599	NAME NOT FOUND	16090905	HALYMENIA	
16090999	NAME NOT FOUND	160909	CRYPTONEMIACEAE	
1609099999	NAME NOT FOUND	160909	CRYPTONEMIACEAE	
160910	KALLYMENIACEAE	160910	KALLYMENIACEAE	
16091001	CALLOCOLAX	16091001	CALLOCOLAX	
16091002	CALLOPHYLLIS	16091002	CALLOPHYLLIS	
1609100202	CALLOPHYLLIS EDENTAT	1609100202	CALLOPHYLLIS EDENTATA	
1609100203	CALLOPHYLLIS FLABELL	1609100203	CALLOPHYLLIS FLABELLULATA	*
1609100204	CALLOPHYLLIS HAENOPH	1609100204	CALLOPHYLLIS HAENOPHYLLA	
1609100206	CALLOPHYLLIS PINNATA	1609100206	CALLOPHYLLIS PINNATA	
1609100208	CALLOPHYLLIS FIRMA	1609100208	CALLOPHYLLIS FIRMA	
1609100209	CALLOPHYLLIS THOMPSO	1609100209	CALLOPHYLLIS THOMPSONII	
1609100299	NAME NOT FOUND	16091002	CALLOPHYLLIS	
1609100302	EUTHORA FRUTICULOSA	1609100302	EUTHORA FRUTICULOSA	
16091007	ERYTHROPHYLLUM	16091007	ERYTHROPHYLLUM	
1609110101	CHOREOCOLAX POLYSIPH	1609110101	CHOREOCOLAX POLYSIPHONIAE	

(continued)

TABLE B-3 (continued)

16091301	CONSTANTINEA	16091301	CONSTANTINEA	
1609130101	CONSTANTINEA ROSA-MA	1609130101	CONSTANTINEA ROSA-MARINA	
1609130102	CONSTANTINEA SIMPLEX	1609130102	CONSTANTINEA SIMPLEX	
1609130103	CONSTANTINEA SUBULIF	1609130103	CONSTANTINEA SUBULIFERA	
16091302	WEEKSIA	16091302	WEEKSIA	
1609130201	WEEKSIA RETICULATA	1609130201	WEEKSIA RETICULATA	
1609130203	WEEKSIA DIGITATA	1609130203	WEEKSIA DIGITATA	
16100202	RHODYMENIA	16100202	RHODYMENIA	¦+
1610020202	RHODYMENIA PACIFICA	1610020202	RHODYMENIA PACIFICA	¦
1610020203	RHODYMENIA PALMATA	1610020203	RHODYMENIA PALMATA	¦
1610020204	RHODYMENIA PERTUSA	1610020204	RHODYMENIA PERTUSA	¦
1610020205	RHODYMENIA STIPITATA	1610020205	RHODYMENIA STIPITATA	¦
1610020401	BOTRYOCLADIA PSEUDOD	1610020401	BOTRYOCLADIA PSEUDODICHOTOMA	
1610020501	HALOSACCION GLANDIFO	1610020501	HALOSACCION GLANDIFORME	
16100206	FAUCHEA	16100206	FAUCHEA	
1610020601	FAUCHEA LACINIATA	1610020601	FAUCHEA LACINIATA	
1610020602	FAUCHEA FRYEANA	1610020602	FAUCHEA FRYEANA	
1610020901	LEPTOFAUCHEA PACIFIC	1610020901	LEPTOFAUCHEA PACIFICA	
16100210	FRYEELLA	16100210	FRYEELLA	
161101	CERAMIACEAE HOM.1	161101	CERAMIACEAE HOM.1	
16110101	ANTITHAMNION	16110101	ANTITHAMNION	¦+
1611010104	ANTITHAMNION DENDROI	1611010104	ANTITHAMNION DENDROIDEUM	¦
1611010106	ANTITHAMNION KYLINII	1611010106	ANTITHAMNION KYLINII	¦
1611010109	ANTITHAMNION DEFECTU	1611010109	ANTITHAMNION DEFECTUM	¦
16110102	CALLITHAMNION	16110102	CALLITHAMNION	
1611010205	CALLITHAMNION BISERI	1611010205	CALLITHAMNION BISERIATUM	
1611010207	CALLITHAMNION PIKEAN	1611010207	CALLITHAMNION PIKEANUM	
1611010208	CALLITHAMNION ACUTUM	1611010208	CALLITHAMNION ACUTUM	
16110103	BORNETIA	16110103	BORNETIA	
16110104	CERAMIUM	16110104	CERAMIUM	
1611010404	CERAMIUM RUBRUM	1611010404	CERAMIUM RUBRUM	
1611010405	CERAMIUM STRICTUM	1611010405	CERAMIUM STRICTUM	+
1611010410	CERAMIUM CALIFORNICU	1611010410	CERAMIUM CALIFORNICUM	
1611010411	CERAMIUM GARDNERI	1611010411	CERAMIUM GARDNERI	
1611010413	CERAMIUM WASHINGTONI	1611010413	CERAMIUM WASHINGTONIENSE	
16110105	GRIFFITHSIA	16110105	GRIFFITHSIA	
1611010501	GRIFFITHSIA TENUIS	16110105	GRIFFITHSIA	
1611010599	NAME NOT FOUND	16110105	GRIFFITHSIA	
1611010701	TRAILLIELLA INTRICAT	1611010701	TRAILLIELLA INTRICATA	
16110113	MICROCLADIA	16110113	MICROCLADIA	
1611011301	MICROCLADIA BOREALIS	1611011301	MICROCLADIA BOREALIS	
1611011302	MICROCLADIA COULTERI	1611011302	MICROCLADIA COULTERI	
16110114	PLEONOSPORIUM	16110114	PLEONOSPORIUM	
1611011403	PLEONOSPORIUM VANCOU	16110114	PLEONOSPORIUM	
1611011499	NAME NOT FOUND	16110114	PLEONOSPORIUM	
16110116	PTILOTA	16110116	PTILOTA	
1611011601	PTILOTA FILICINA	1611011601	PTILOTA FILICINA	
1611011602	PTILOTA PECTINATA	1611011602	PTILOTA PECTINATA	

(continued)

TABLE B-3 (continued)

1611011603	PTILOTA TENUIS	1611011603	PTILOTA TENUIS	
16110122	ANTITHAMNIONELLA	16110122	ANTITHAMNIONELLA	
1611012201	ANTITHAMNIONELLA GLA	1611012201	ANTITHAMNIONELLA GLANDULIFERA	
1611012202	ANTITHAMNIONELLA PAC	1611012202	ANTITHAMNIONELLA PACIFICA	
16110123	PLATYTHAMNION	16110123	PLATYTHAMNION	¦+
1611012301	PLATYTHAMNION PECTIN	1611012301	PLATYTHAMNION PECTINATUM	¦
1611012302	PLATYTHAMNION VILLOS	1611012302	PLATYTHAMNION VILLOSUM	¦
1611012303	PLATYTHAMNION REVERS	1611012303	PLATYTHAMNION REVERSUM	¦
1611012304	PLATYTHAMNION HETERO	1611012304	PLATYTHAMNION HETEROMORPHUM	¦
1611012396	NAME NOT FOUND	16110123	PLATYTHAMNION	¦
16110124	NEOPTILOTA	16110124	NEOPTILOTA	
1611012401	NEOPTILOTA ASPLENIOI	16110124	NEOPTILOTA	
16110125	HOLLENBERGIA	16110125	HOLLENBERGIA	
1611012501	HOLLENBERGIA SUBULAT	1611012501	HOLLENBERGIA SUBULATA	
1611012502	HOLLENBERGIA NIGRICA	1611012502	HOLLENBERGIA NIGRICANS	
16110126	SCAGELONEMA/SCAGELIA	16110126	SCAGELONEMA/SCAGELIA	¦+
1611012601	SCAGELIA OCCIDENTALE	16110126	SCAGELONEMA/SCAGELIA	¦
16110127	TIFFANIELLA	16110127	TIFFANIELLA	
1611012701	TIFFANIELLA SNYDERAE	16110127	TIFFANIELLA	
1611012899	NAME NOT FOUND	16110128	PTILOTHAMNIONOPSIS	
161102	DELESSERIACEAE	161102	DELESSERIACEAE	
16110205	CRYPTOPLEURA	16110205	CRYPTOPLEURA	
1611020501	CRYPTOPLEURA RUPRECH	16110205	CRYPTOPLEURA	
1611020502	CRYPTOPLEURA LOBULIF	16110205	CRYPTOPLEURA	
1611020503	CRYPTOPLEURA VIOLACE	16110205	CRYPTOPLEURA	
16110206	DELESSERIA	16110206	DELESSERIA	
1611020601	DELESSERIA DECIPIENS	16110206	DELESSERIA	
1611020901	GONIMOPHYLLUM SKOTTS	1611020901	GONIMOPHYLLUM SKOTTSBERGII	
16110211	MEMBRANOPTERA	16110211	MEMBRANOPTERA	
1611021103	MEMBRANOPTERA PLATYP	1611021103	MEMBRANOPTERA PLATYPHYLLA	
1611021108	MEMBRANOPTERA MULTIR	1611021108	MEMBRANOPTERA MULTIRAMOSA	
1611021109	MEMBRANOPTERA WEEKSI	1611021109	MEMBRANOPTERA WEEKSIAE	
16110212	NITOPHYLLUM	16110212	NITOPHYLLUM	
1611021299	NAME NOT FOUND	16110212	NITOPHYLLUM	
16110214	PHYCODRYS	16110214	PHYCODRYS	
1611021405	PHYCODRYS ISABELLIAE	16110214	PHYCODRYS	
16110215	POLYNEURA	16110215	POLYNEURA	¦*
1611021501	POLYNEURA LATISSIMA	16110215	POLYNEURA	¦
16110217	MYRIOGRAMME	16110217	MYRIOGRAMME	
1611022003	NIENBURGIA ANDERSONI	1611022003	NIENBURGIA ANDERSONIANA	+
16110223	ASTEROCOLAX	16110223	ASTEROCOLAX	
1611022399	NAME NOT FOUND	16110223	ASTEROCOLAX	
16110224	HYMENENA	16110224	HYMENENA	
1611022402	HYMENENA FLABELLIGER	16110224	HYMENENA	
1611022404	HYMENENA SETCHELLII	16110224	HYMENENA	
1611022499	NAME NOT FOUND	16110224	HYMENENA	
16110225	BOTRYOGLOSSUM	16110225	BOTRYOGLOSSUM	
1611022501	BOTRYOGLOSSUM FARLOW	16110225	BOTRYOGLOSSUM	

(continued)

TABLE B-3 (continued)

1611022799	NAME NOT FOUND	16110225	BOTRYOGLOSSUM	
16110302	HETEROSIPHONIA	16110302	HETEROSIPHONIA	
1611030201	HETEROSIPHONIA DENSI	16110302	HETEROSIPHONIA	
16110303	RHODOPTILUM	16110303	RHODOPTILUM	
1611030301	RHODOPTILUM PLUMOSUM	16110303	RHODOPTILUM	
16110401	POLYSIPHONIA	16110401	POLYSIPHONIA	
1611040101	POLYSIPHONIA HENDRYI	1611040101	POLYSIPHONIA HENDRYI	+
1611040103	POLYSIPHONIA PACIFIC	1611040103	POLYSIPHONIA PACIFICA	
1611040114	POLYSIPHONIA PANICUL	1611040114	POLYSIPHONIA PANICULATA	
16110402	PTEROSIPHONIA	16110402	PTEROSIPHONIA	
1611040202	PTEROSIPHONIA BIPINN	1611040202	PTEROSIPHONIA BIPINNATA	
1611040203	PTEROSIPHONIA DENDRO	1611040203	PTEROSIPHONIA DENDROIDEA	+
1611040204	PTEROSIPHONIA GARDNE	1611040204	PTEROSIPHONIA GARDNERI	
1611040205	PTEROSIPHONIA GRACIL	1611040205	PTEROSIPHONIA GRACILIS	
1611040301	AMPLISIPHONIA PACIFI	1611040301	AMPLISIPHONIA PACIFICA	
1611040401	LAURENCIA SPECTABILI	1611040401	LAURENCIA SPECTABILIS	
16110405	RHODOMELA	16110405	RHODOMELA	
1611040501	RHODOMELA LARIX	16110405	RHODOMELA	
16110406	ODONTHALIA	16110406	ODONTHALIA	
1611040603	ODONTHALIA FLOCCOSA	1611040603	ODONTHALIA FLOCCOSA	*
1611040605	ODONTHALIA LYALLII	1611040605	ODONTHALIA LYALLII	
1611040606	ODONTHALIA WASHINGTO	1611040606	ODONTHALIA WASHINGTONIENSIS	
1611040607	ODONTHALIA KAMTSCHAT	1611040607	ODONTHALIA KAMTSCHATICA	
16110407	LOPHOSIPHONIA	16110407	LOPHOSIPHONIA	
1611040701	LOPHOSIPHONIA VILLUM	1611040701	LOPHOSIPHONIA VILLUM	
1611040702	LOPHOSIPHONIA REPTAB	1611040702	LOPHOSIPHONIA REPTABUNDA	
16110412	HERPOSIPHONIA	16110412	HERPOSIPHONIA	
1611041201	HERPOSIPHONIA VERTIC	1611041201	HERPOSIPHONIA VERTICILLATA	
1611041202	HERPOSIPHONIA GRANDI	1611041202	HERPOSIPHONIA GRANDIS	
1611041203	HERPOSIPHONIA PLUMUL	1611041203	HERPOSIPHONIA PLUMULA	
16110413	PTEROCHONDRIA	16110413	PTEROCHONDRIA	
1611041301	PTEROCHONDRIA WOODII	16110413	PTEROCHONDRIA	
16110414	JANCZEWSKIA	16110414	JANCZEWSKIA	
3326010101	ZOSTERA MARINA	3326010101	ZOSTERA MARINA	*
33260103	PHYLLOSPADIX	33260103	PHYLLOSPADIX	¦+
3326010301	PHYLLOSPADIX SCOULER	33260103	PHYLLOSPADIX	¦
333101	IRIDACEAE	333101	IRIDACEAE	
36	PORIFERA	36	PORIFERA	
3664020801	SIGMODOCIA EDAPHUS	36	PORIFERA	
37	CNIDARIA	37	CNIDARIA	
3701	HYDROZOA	3701	HYDROZOA	
3702	HYDROZOA HYDROIDA	3702	HYDROZOA HYDROIDA	
37030301	CORYMORPHA	37030301	CORYMORPHA	
37030302	TUBULARIA	37030302	TUBULARIA	
3703060101	CORYNE TUBULOSA	3703060101	CORYNE TUBULOSA	
37040101	CAMPANULARIA	37040101	CAMPANULARIA	
37040102	OBELIA	37040102	OBELIA	
37040404	CALICELLA	37040404	CALICELLA	

(continued)

TABLE B-3 (continued)

37040503	SERTULARIA	37040503	SERTULARIA
37040504	ABIETINARIA	37040504	ABIETINARIA
37040508	DIPHASIA	37040508	DIPHASIA
37040601	HALECIUM	37040601	HALECIUM
37040701	PLUMULARIA	37040701	PLUMULARIA
37040711	AGLAOPHENIA	37040711	AGLAOPHENIA
3730	SCYPHOZOA	3730	SCYPHOZOA
37310101	HALICLYSTUS	37310101	HALICLYSTUS
3731010101	HALICLYSTUS AURICULA	37310101	HALICLYSTUS
3740	ANTHOZOA	3740	ANTHOZOA
3754020201	PTILOSARCUS GURNEYI	3754020201	PTILOSARCUS GURNEYI
3758	ZOANTHARIA ACTINIARI	3758	ZOANTHARIA ACTINIARIA
3759	ZOANTHARIA ACTINIARI	3759	ZOANTHARIA ACTINIARIA NYNANTHEAE
375904	HALCAMPIDAE	375904	HALCAMPIDAE
37590401	HALCAMPA	375904	HALCAMPIDAE
3759040101	HALCAMPA DECEMTENTAC	375904	HALCAMPIDAE
37590499	NAME NOT FOUND	375904	HALCAMPIDAE
3759049999	NAME NOT FOUND	375904	HALCAMPIDAE
3760	ZOANTHARIA ACTINIARI	3760	ZOANTHARIA ACTINIARIA NYNANTHEAE
3760010201	ANTHOPLEURA ELEGANTI	3760010201	ANTHOPLEURA ELEGANTISSIMA
3760010301	EPIACTIS PROLIFERA	3760010301	EPIACTIS PROLIFERA
3760019799	NAME NOT FOUND	376001	ACTINIIDAE
3760060101	METRIDIUM SENILE	3760060101	METRIDIUM SENILE
3764999999	NAME NOT FOUND	3764	ZOANTHARIA SCLERACTINIA
3769010101	BALANOPHYLLIA ELEGAN	3769010101	BALANOPHYLLIA ELEGANS
39	PLATYHELMINTHES	39	PLATYHELMINTHES
3901	TURBELLARIA	39	PLATYHELMINTHES
3915030298	NAME NOT FOUND	39	PLATYHELMINTHES
43	RHYNCHOCOELA	43	RHYNCHOCOELA
4302010104	TUBULANUS PELLUCIDUS	4302010104	TUBULANUS PELLUCIDUS
43030202	CEREBRATULUS	43030202	CEREBRATULUS
4303020208	CEREBRATULUS CALIFOR	43030202	CEREBRATULUS
4306010102	EMPLECTONEMA GRACILE	4306010102	EMPLECTONEMA GRACILE
4306010603	PARANEMERTES PEREGRI	4306010603	PARANEMERTES PEREGRINA
4306050102	AMPHIPORUS BIMACULAT	4306050102	AMPHIPORUS BIMACULATUS
47	NEMATODA	47	NEMATODA
5001	POLYCHAETA	5001	POLYCHAETA
50010	NAME NOT FOUND	5001	POLYCHAETA
500102	POLYNOIDAE	500102	POLYNOIDAE
5001020402	ARCTONOE VITTATA	5001020402	ARCTONOE VITTATA
50010205	EUNOE	50010205	EUNOE
5001020504	EUNOE SENTA	5001020504	EUNOE SENTA
5001020505	EUNOE OERSTEDI	5001020505	EUNOE OERSTEDI
5001020606	GATTYANA TREADWELLI	5001020606	GATTYANA TREADWELLI
5001020701	HALOSYDNA BREVISETOS	5001020701	HALOSYDNA BREVISETOSA
50010208	HARMOTHOE	50010208	HARMOTHOE
5001020803	HARMOTHOE EXTENUATA	5001020803	HARMOTHOE EXTENUATA
5001020806	HARMOTHOE IMBRICATA	5001020806	HARMOTHOE IMBRICATA

(continued)

TABLE B-3 (continued)

5001020809	HARMOTHOE MULTISETOS	5001020809	HARMOTHOE MULTISETOSA	
5001020810	HARMOTHOE LUNULATA	5001020810	HARMOTHOE LUNULATA	
5001021103	LEPIDONOTUS SQUAMATU	5001021103	LEPIDONOTUS SQUAMATUS	
50010218	LEPIDASTHENIA	50010218	LEPIDASTHENIA	
5001021801	LEPIDASTHENIA BERKEL	50010218	LEPIDASTHENIA	
5001029999	NAME NOT FOUND	500102	POLYNOIDAE	
5001030101	PEISIDICE ASPERA	5001030101	PEISIDICE ASPERA	
500106	SIGALIONIDAE	500106	SIGALIONIDAE	¦*
50010601	PHOLOE	500106	SIGALIONIDAE	¦
5001060101	PHOLOE MINUTA	500106	SIGALIONIDAE	¦
5001069999	NAME NOT FOUND	500106	SIGALIONIDAE	¦
50010701	PISIONE	50010701	PISIONE	
50010801	PALEANOTUS	50010801	PALEANOTUS	
5001080101	PALEANOTUS BELLIS	50010801	PALEANOTUS	
500113	PHYLLODOCIDAE	500113	PHYLLODOCIDAE	
50011301	ANAITIDES/PHYLLODOCE	50011301	ANAITIDES/PHYLLODOCE	
5001130101	ANAITIDES CITRINA	5001130101	ANAITIDES CITRINA	
5001130102	ANAITIDES GROENLANDI	5001130102	ANAITIDES GROENLANDICA	
5001130103	ANAITIDES MEDIPAPILL	5001130103	ANAITIDES MEDIPAPILLATA	
5001130104	ANAITIDES MUCOSA	5001130104	ANAITIDES MUCOSA	
5001130106	ANAITIDES MACULATA	5001130106	ANAITIDES MACULATA	*
5001130107	ANAITIDES MADEIRENSI	5001130107	ANAITIDES MADEIRENSIS	
5001130198	NAME NOT FOUND	50011301	ANAITIDES/PHYLLODOCE	
5001130199	NAME NOT FOUND	50011301	ANAITIDES/PHYLLODOCE	
50011302	ETEONE	50011302	ETEONE	
5001130203	ETEONE PACIFICA	5001130203	ETEONE PACIFICA	
5001130205	ETEONE LONGA	5001130205	ETEONE LONGA	+
5001130206	ETEONE TUBERCULATA	5001130206	ETEONE TUBERCULATA	
50011303	EULALIA	50011303	EULALIA	¦+
5001130301	EULALIA VIRIDIS	5001130301	EULALIA VIRIDIS	¦
5001130302	EULALIA SANGUINEA	5001130302	EULALIA SANGUINEA	¦
5001130304	EULALIA BILINEATA	5001130304	EULALIA BILINEATA	¦
5001130305	EULALIA MACROCEROS	5001130305	EULALIA MACROCEROS	¦
5001130306	EULALIA QUADRIOCULAT	5001130306	EULALIA QUADRIOCULATA	¦
5001130307	EULALIA NIGRIMACULAT	5001130307	EULALIA NIGRIMACULATA	¦
5001130402	NOTOPHYLLUM IMBRICAT	5001130402	NOTOPHYLLUM IMBRICATUM	
50011307	GENETYLLIS	50011307	GENETYLLIS	
5001130701	GENETYLLIS CASTANEA	50011307	GENETYLLIS	
5001130901	HESIONURA COINEAUI	5001130901	HESIONURA COINEAUI	+
500121	HESIONIDAE	500121	HESIONIDAE	
5001210102	GYPTIS BREVIPALPA	5001210102	GYPTIS BREVIPALPA	
5001210401	OPHIODROMUS PUGETTEN	5001210401	OPHIODROMUS PUGETTENSIS	
5001210501	KEFERSTEINIA CIRRATA	5001210501	KEFERSTEINIA CIRRATA	
5001210801	MICROPODARKE DUBIA	5001210801	MICROPODARKE DUBIA	*
50012109	SYLLIDIA	50012109	SYLLIDIA	
5001219899	NAME NOT FOUND	500121	HESIONIDAE	
5001219999	NAME NOT FOUND	500121	HESIONIDAE	
5001220201	SIGAMBRA TENTACULATA	5001220201	SIGAMBRA TENTACULATA	

(continued)

TABLE B-3 (continued)

5001220301	PILARGIS BERKELEYAE	5001220301	PILARGIS BERKELEYAE	
500123	SYLLIDAE	500123	SYLLIDAE	
50012301	AUTOLYTUS	50012301	AUTOLYTUS	
5001230101	AUTOLYTUS CORNUTUS	50012301	AUTOLYTUS	
50012302	PIONOSYLLIS	50012302	PIONOSYLLIS	¦+
5001230204	PIONOSYLLIS URAGA	50012302	PIONOSYLLIS	¦
50012303	SYLLIS	50012303	SYLLIS	+
5001230401	TRYPANOSYLLIS GEMMIP	5001230401	TRYPANOSYLLIS GEMMIPARA	
50012305	TYPOSYLLIS	50012305	TYPOSYLLIS	¦+
5001230501	TYPOSYLLIS ALTERNATA	5001230501	TYPOSYLLIS ALTERNATA	¦
5001230502	TYPOSYLLIS ARMILLARI	5001230502	TYPOSYLLIS ARMILLARIS	¦
5001230506	TYPOSYLLIS STEWARTI	5001230506	TYPOSYLLIS STEWARTI	¦
5001230507	TYPOSYLLIS FASCIATA	5001230507	TYPOSYLLIS FASCIATA	¦
5001230511	TYPOSYLLIS HYALINA	5001230511	TYPOSYLLIS HYALINA	¦
5001230512	TYPOSYLLIS VARIEGATA	5001230512	TYPOSYLLIS VARIEGATA	¦
50012306	EUSYLLIS	50012306	EUSYLLIS	
5001230602	EUSYLLIS BLOMSTRANDI	50012306	EUSYLLIS	
5001230603	EUSYLLIS JAPONICA	50012306	EUSYLLIS	
5001230604	EUSYLLIS MAGNIFICA	50012306	EUSYLLIS	
50012307	EXOGONE	50012307	EXOGONE	¦+
5001230702	EXOGONE GEMMIFERA	5001230702	EXOGONE GEMMIFERA	¦
5001230703	EXOGONE LOUREI	5001230703	EXOGONE LOUREI	¦
5001230704	EXOGONE MOLESTA	5001230704	EXOGONE MOLESTA	¦
50012308	SPHAEROSYLLIS	50012308	SPHAEROSYLLIS	
5001230805	SPHAEROSYLLIS PERIFE	5001230805	SPHAEROSYLLIS PERIFERA	+
5001230806	SPHAEROSYLLIS BRANDH	5001230806	SPHAEROSYLLIS BRANDHORSTI	
5001230901	BRANIA BREVIPHARYNGE	5001230901	BRANIA BREVIPHARYNGEA	
5001231002	LANGERHANSIA HETEROC	5001231002	LANGERHANSIA HETEROCHAETA	
50012313	ODONTOSYLLIS	50012313	ODONTOSYLLIS	
5001231302	ODONTOSYLLIS PARVA	50012313	ODONTOSYLLIS	
50012315	SYLLIDES	50012315	SYLLIDES	
5001231503	SYLLIDES LONGOCIRRAT	50012315	SYLLIDES	
5001231599	NAME NOT FOUND	50012315	SYLLIDES	
5001231604	STREPTOSYLLIS LATIPA	5001231604	STREPTOSYLLIS LATIPALPA	
5001239999	NAME NOT FOUND	500123	SYLLIDAE	
500124	NEREIDAE	500124	NEREIDAE	
5001240201	CHEILONEREIS CYCLURU	5001240201	CHEILONEREIS CYCLURUS	
50012403	NEANTHES	50012403	NEANTHES	
5001240301	NEANTHES BRANDTI	50012403	NEANTHES	
50012404	NEREIS	50012404	NEREIS	¦+
5001240403	NEREIS PELAGICA	5001240403	NEREIS PELAGICA	¦
5001240404	NEREIS PROCERA	5001240404	NEREIS PROCERA	¦
5001240405	NEREIS VEXILLOSA	5001240405	NEREIS VEXILLOSA	¦
5001240406	NEREIS ZONATA	5001240406	NEREIS ZONATA	¦
5001240501	PLATYNEREIS BICANALI	5001240501	PLATYNEREIS BICANALICULATA	*
5001240701	MICRONEREIS NANAIMOE	5001240701	MICRONEREIS NANAIMOENSIS	
50012501	NEPHTYS	50012501	NEPHTYS	¦+
5001250102	NEPHTYS CILIATA	5001250102	NEPHTYS CILIATA	¦

(continued)

TABLE B-3 (continued)

5001250103	NEPHTYS CAECA	5001250103	NEPHTYS CAECA	¦
5001250109	NEPHTYS LONGOSETOSA	5001250109	NEPHTYS LONGOSETOSA	¦
5001250111	NEPHTYS FERRUGINEA	5001250111	NEPHTYS FERRUGINEA	¦
5001250113	NEPHTYS CALIFORNIENS	5001250113	NEPHTYS CALIFORNIENSIS	¦
5001250119	NEPHTYS CAECOIDES	5001250119	NEPHTYS CAECOIDES	¦
5001250199	NAME NOT FOUND	50012501	NEPHTYS	¦
500126	SPHAERODORIDAE	500126	SPHAERODORIDAE	
5001260102	SPHAERODORUM PAPILLI	5001260102	SPHAERODORUM PAPILLIFER	
5001260201	SPHAERODOROPSIS MINU	5001260201	SPHAERODOROPSIS MINUTA	
5001260202	SPHAERODOROPSIS SPHA	5001260202	SPHAERODOROPSIS SPHAERULIFER	
50012701	GLYCERA (POLYCHAE	50012701	GLYCERA (POLYCHAETA)	
5001270101	GLYCERA CAPITATA	5001270101	GLYCERA CAPITATA	
5001270103	GLYCERA TESSELATA	5001270103	GLYCERA TESSELATA	
5001270104	GLYCERA AMERICANA	5001270104	GLYCERA AMERICANA	
5001270201	HEMIPODUS BOREALIS	5001270201	HEMIPODUS BOREALIS	*
50012801	GLYCINDE	50012801	GLYCINDE	
5001280101	GLYCINDE PICTA	5001280101	GLYCINDE PICTA	+
5001280103	GLYCINDE ARMIGERA	5001280103	GLYCINDE ARMIGERA	
50012802	GONIADA	50012802	GONIADA	
5001280202	GONIADA MACULATA	5001280202	GONIADA MACULATA	
5001280203	GONIADA BRUNNEA	5001280203	GONIADA BRUNNEA	
50012901	ONUPHIS	50012901	ONUPHIS	¦+
5001290101	ONUPHIS CONCHYLEGA	5001290101	ONUPHIS CONCHYLEGA	¦
5001290103	ONUPHIS IRIDESCENS	5001290103	ONUPHIS IRIDESCENS	¦
5001290106	ONUPHIS STIGMATIS	5001290106	ONUPHIS STIGMATIS	¦
5001290111	ONUPHIS ELEGANS	5001290111	ONUPHIS ELEGANS	¦
5001290199	NAME NOT FOUND	50012901	ONUPHIS	¦
5001290202	DIOPATRA ORNATA	50012902	DIOPATRA	
5001290299	NAME NOT FOUND	50012902	DIOPATRA	
5001300102	EUNICE VALENS	5001300102	EUNICE VALENS	
50013101	LUMBRINEREIS	50013101	LUMBRINEREIS	¦+
5001310106	LUMBRINEREIS ZONATA	5001310106	LUMBRINEREIS ZONATA	¦
5001310108	LUMBRINEREIS INFLATA	5001310108	LUMBRINEREIS INFLATA	¦
5001310109	LUMBRINEREIS LUTI	5001310109	LUMBRINEREIS LUTI	¦
5001330201	ARABELLA IRICOLOR	5001330201	ARABELLA IRICOLOR	
50013601	DORVILLEA/SCHISTOMER	50013601	DORVILLEA/SCHISTOMERINGOS	
5001360103	DORVILLEA JAPONICA	5001360103	DORVILLEA JAPONICA	
5001360104	DORVILLEA RUDOLPHI	5001360104	DORVILLEA RUDOLPHI	
5001360105	DORVILLEA ANNULATA	5001360105	DORVILLEA ANNULATA	
5001360201	PROTODORVILLEA GRACI	5001360201	PROTODORVILLEA GRACILIS	*
5001360202	PROTODORVILLEA GASPE	5001360202	PROTODORVILLEA GASPEENSIS	
500140	ORBINIIDAE	500140	ORBINIIDAE	
5001400102	HAPLOSCOLOPLOS ELONG	5001400102	HAPLOSCOLOPLOS ELONGATUS	
50014002	NAINERIS	50014002	NAINERIS	
5001400201	NAINERIS DENDRITICA	5001400201	NAINERIS DENDRITICA	
5001400202	NAINERIS QUADRICUSPI	5001400202	NAINERIS QUADRICUSPIDA	
5001400203	NAINERIS LAEVIGATA	5001400203	NAINERIS LAEVIGATA	
5001400204	NAINERIS UNCINATA	5001400204	NAINERIS UNCINATA	

(continued)

TABLE B-3 (continued)

50014003	SCOLOPLOS	50014003	SCOLOPLOS	
5001400301	SCOLOPLOS ARMIGER	5001400301	SCOLOPLOS ARMIGER	
5001400302	SCOLOPLOS PUGETTENSI	5001400302	SCOLOPLOS PUGETTENSIS	*
5001400401	PHYLO FELIX	5001400401	PHYLO FELIX	
50014005	ORBINIA	50014005	ORBINIA	
5001400501	ORBINIA MICHAELSENI	50014005	ORBINIA	
500141	PARAONIDAE	500141	PARAONIDAE	
50014102	ARICIDEA	50014102	ARICIDEA	¦+
5001410201	ARICIDEA SUECICA	50014102	ARICIDEA	¦
5001410299	NAME NOT FOUND	50014102	ARICIDEA	¦
50014103	PARAONIS	50014103	PARAONIS	
5001410301	PARAONIS GRACILIS	5001410301	PARAONIS GRACILIS	
5001410304	PARAONIS LYRA	5001410304	PARAONIS LYRA	
50014105	PARAONELLA	50014105	PARAONELLA	¦+
5001410501	PARAONELLA PLATYBRAN	50014105	PARAONELLA	¦
50014201	APISTOBRANCHUS	50014201	APISTOBRANCHUS	
500143	SPIONIDAE	500143	SPIONIDAE	
50014302	LAONICE	50014302	LAONICE	¦+
5001430201	LAONICE CIRRATA	50014302	LAONICE	¦
50014303	NERINE	50014303	NERINE	
5001430303	NERINE FOLIOSA	50014303	NERINE	
50014304	POLYDORA	50014304	POLYDORA	
5001430402	POLYDORA SOCIALIS	5001430402	POLYDORA SOCIALIS	+
5001430404	POLYDORA CAULLERYI	5001430404	POLYDORA CAULLERYI	
5001430408	POLYDORA QUADRILOBAT	5001430408	POLYDORA QUADRILOBATA	
5001430409	POLYDORA SPONGICOLA	5001430409	POLYDORA SPONGICOLA	
5001430417	POLYDORA PYGIDIALIS	5001430417	POLYDORA PYGIDIALIS	
5001430492	NAME NOT FOUND	50014304	POLYDORA	
5001430495	NAME NOT FOUND	50014304	POLYDORA	
5001430496	NAME NOT FOUND	50014304	POLYDORA	
5001430499	NAME NOT FOUND	50014304	POLYDORA	
50014305	PRIONOSPIO	50014305	PRIONOSPIO	
5001430502	PRIONOSPIO CIRRIFERA	5001430502	PRIONOSPIO CIRRIFERA	+
5001430504	PRIONOSPIO PINNATA	5001430504	PRIONOSPIO PINNATA	
5001430506	PRIONOSPIO STEENSTRU	5001430506	PRIONOSPIO STEENSTRUPI	*
5001430508	PRIONOSPIO CIRROBRAN	5001430508	PRIONOSPIO CIRROBRANCHIATA	
50014307	SPIO	50014307	SPIO	
5001430701	SPIO FILICORNIS	5001430701	SPIO FILICORNIS	*
5001430703	SPIO CIRRIFERA	5001430703	SPIO CIRRIFERA	
50014308	BOCCARDIA	50014308	BOCCARDIA	
5001430801	BOCCARDIA COLUMBIANA	5001430801	BOCCARDIA COLUMBIANA	
5001430806	BOCCARDIA HAMATA	5001430806	BOCCARDIA HAMATA	
50014310	SPIOPHANES	50014310	SPIOPHANES	
5001431001	SPIOPHANES BOMBYX	5001431001	SPIOPHANES BOMBYX	*
5001431003	SPIOPHANES CIRRATA	5001431003	SPIOPHANES CIRRATA	
5001431004	SPIOPHANES BERKELEYO	5001431004	SPIOPHANES BERKELEYORUM	
50014312	RHYNCHOSPIO	50014312	RHYNCHOSPIO	
5001431302	PYGOSPIO ELEGANS	5001431302	PYGOSPIO ELEGANS	

(continued)

TABLE B-3 (continued)

50014314	MALACOCEROS	50014314	MALACOCEROS	¦*
5001431401	MALACOCEROS GLUTAEUS	50014314	MALACOCEROS	¦
5001431501	PSEUDOPOLYDORA KEMPI	5001431501	PSEUDOPOLYDORA KEMPI	
5001431701	PARAPRIONOSPIO PINNA	5001431701	PARAPRIONOSPIO PINNATA	
5001431801	STREBLOSPIO BENEDICT	5001431801	STREBLOSPIO BENEDICTI	
5001432001	SCOLELEPIS SQUAMATA	50014320	SCOLELEPIS	
5001432099	NAME NOT FOUND	50014320	SCOLELEPIS	
50014322	AONIDES	50014322	AONIDES	
50014401	MAGELONA	50014401	MAGELONA	
5001440101	MAGELONA JAPONICA	5001440101	MAGELONA JAPONICA	
5001440103	MAGELONA PITELKAI	5001440103	MAGELONA PITELKAI	+
5001490202	PHYLLOCHAETOPTERUS P	50014902	PHYLLOCHAETOPTERUS	
5001490299	NAME NOT FOUND	50014902	PHYLLOCHAETOPTERUS	
5001490302	SPIOCHAETOPTERUS COS	5001490302	SPIOCHAETOPTERUS COSTARUM	
5001490401	MESOCHAETOPTERUS TAY	5001490401	MESOCHAETOPTERUS TAYLORI	
500150	CIRRATULIDAE	500150	CIRRATULIDAE	
50015001	CIRRATULUS	50015001	CIRRATULUS	¦+
5001500101	CIRRATULUS CIRRATUS	50015001	CIRRATULUS	¦
50015002	CAULLERIELLA	50015002	CAULLERIELLA	
5001500202	CAULLERIELLA ALATA	5001500202	CAULLERIELLA ALATA	
5001500203	CAULLERIELLA GRACILI	5001500203	CAULLERIELLA GRACILIS	
5001500299	NAME NOT FOUND	50015002	CAULLERIELLA	
50015003	THARYX	50015003	THARYX	¦+
5001500302	THARYX MULTIFILIS	50015003	THARYX	¦
50015004	CHAETOZONE	50015004	CHAETOZONE	
5001500401	CHAETOZONE SETOSA	5001500401	CHAETOZONE SETOSA	+
5001500402	CHAETOZONE GRACILIS	5001500402	CHAETOZONE GRACILIS	
50015005	DODECACERIA	50015005	DODECACERIA	
5001500501	DODECACERIA CONCHARU	50015005	DODECACERIA	
50015006	CIRRIFORMIA	50015006	CIRRIFORMIA	
500151	ACROCIRRIDAE	500151	ACROCIRRIDAE	
50015101	ACROCIRRUS	500151	ACROCIRRIDAE	
5001510101	ACROCIRRUS HETEROCHA	500151	ACROCIRRIDAE	
50015401	BRADA	50015401	BRADA	
5001540201	FLABELLIGERA INFUNDI	5001540201	FLABELLIGERA INFUNDIBULARIS	
5001540202	FLABELLIGERA AFFINIS	5001540202	FLABELLIGERA AFFINIS	
5001540302	PHERUSA PLUMOSA	5001540302	PHERUSA PLUMOSA	
5001570101	SCALIBREGMA INFLATUM	5001570101	SCALIBREGMA INFLATUM	*
50015801	OPHELINA	50015801	OPHELINA	
5001580101	AMMOTRYPANE AULOGAST	50015801	OPHELINA	
5001580202	ARMANDIA BREVIS	5001580202	ARMANDIA BREVIS	*
50015803	OPHELIA	50015803	OPHELIA	
5001580301	OPHELIA LIMACINA	50015803	OPHELIA	
5001580401	TRAVISIA BREVIS	5001580401	TRAVISIA BREVIS	
5001580402	TRAVISIA FORBESII	5001580402	TRAVISIA FORBESII	
5001580403	TRAVISIA PUPA	5001580403	TRAVISIA PUPA	
50015901	STERNASPIS	50015901	STERNASPIS	
5001590101	STERNASPIS SCUTATA	50015901	STERNASPIS	

(continued)

TABLE B-3 (continued)

500160	CAPITELLIDAE	500160	CAPITELLIDAE	
50016001	CAPITELLA	50016001	CAPITELLA	¦*
5001600101	CAPITELLA CAPITATA	50016001	CAPITELLA	¦
50016003	NOTOMASTUS	50016003	NOTOMASTUS	
5001600301	NOTOMASTUS GIGANTEUS	5001600301	NOTOMASTUS GIGANTEUS	
5001600302	NOTOMASTUS TENUIS	5001600302	NOTOMASTUS TENUIS	
5001600303	NOTOMASTUS LINEATUS	5001600303	NOTOMASTUS LINEATUS	
5001600305	NOTOMASTUS LURIDUS	5001600305	NOTOMASTUS LURIDUS	
50016004	MEDIOMASTUS	50016004	MEDIOMASTUS	¦*
5001600401	MEDIOMASTUS AMBISETA	50016004	MEDIOMASTUS	¦
5001600501	DECAMASTUS GRACILIS	5001600501	DECAMASTUS GRACILIS	
5001609999	NAME NOT FOUND	500160	CAPITELLIDAE	
50016203	BRANCHIOMALDANE	50016203	BRANCHIOMALDANE	
5001620301	BRANCHIOMALDANE VICE	50016203	BRANCHIOMALDANE	
500163	MALDANIDAE	500163	MALDANIDAE	
50016303	MALDANE	50016303	MALDANE	
5001630301	MALDANE SARSI	5001630301	MALDANE SARSI	
5001630302	MALDANE GLEBIFEX	5001630302	MALDANE GLEBIFEX	
50016305	NICOMACHE	50016305	NICOMACHE	
5001630501	NICOMACHE LUMBRICALI	5001630501	NICOMACHE LUMBRICALIS	
5001630502	NICOMACHE PERSONATA	5001630502	NICOMACHE PERSONATA	*
5001630601	NOTOPROCTUS PACIFICU	5001630601	NOTOPROCTUS PACIFICUS	
50016307	PETALOPROCTUS	50016307	PETALOPROCTUS	
5001630701	PETALOPROCTUS TENUIS	50016307	PETALOPROCTUS	
5001630802	AXIOTHELLA RUBROCINC	5001630802	AXIOTHELLA RUBROCINCTA	*
50016309	PRAXILLELLA	50016309	PRAXILLELLA	
5001630901	PRAXILLELLA GRACILIS	5001630901	PRAXILLELLA GRACILIS	
5001630903	PRAXILLELLA AFFINIS	5001630903	PRAXILLELLA AFFINIS	
50016311	EUCLYMENE	50016311	EUCLYMENE	
5001631101	EUCLYMENE DELINEATA	50016311	EUCLYMENE	
50016320	ISOCIRRUS	50016320	ISOCIRRUS	
500164	OWENIIDAE	500164	OWENIIDAE	
5001640102	OWENIA FUSIFORMIS	5001640102	OWENIA FUSIFORMIS	*
5001640202	MYRIOCHELE OCULATA	5001640202	MYRIOCHELE OCULATA	
5001650102	IDANTHYRSUS ARMATUS	5001650102	IDANTHYRSUS ARMATUS	
5001650201	SABELLARIA CEMENTARI	5001650201	SABELLARIA CEMENTARIUM	
5001660202	CISTENIDES GRANULATA	5001660202	CISTENIDES GRANULATA	+
50016603	PECTINARIA	50016603	PECTINARIA	
5001660301	PECTINARIA BELGICA	5001660301	PECTINARIA BELGICA	
5001660303	PECTINARIA GRANULATA	5001660303	PECTINARIA GRANULATA	
500167	AMPHARETIDAE	500167	AMPHARETIDAE	
50016702	AMPHARETE	50016702	AMPHARETE	¦+
5001670201	AMPHARETE ARCTICA	50016702	AMPHARETE	¦
50016703	AMPHICTEIS	50016703	AMPHICTEIS	
5001670501	MELINNA CRISTATA	5001670501	MELINNA CRISTATA	
50016708	ASABELLIDES	50016708	ASABELLIDES	
5001670801	ASABELLIDES SIBIRICA	5001670801	ASABELLIDES SIBIRICA	
5001670803	ASABELLIDES LITTORAL	5001670803	ASABELLIDES LITTORALIS	

(continued)

TABLE B-3 (continued)

5001670804	ASABELLIDES LINEATA	5001670804	ASABELLIDES LINEATA	
50016710	MELINNEXIS	50016710	MELINNEXIS	
5001671101	PSEUDOSABELLIDES LIT	5001671101	PSEUDOSABELLIDES LITTORALIS	
50016714	SAMYTHA	50016714	SAMYTHA	
5001671801	NAME NOT FOUND	500167	AMPHARETIDAE	
500168	TEREBELLIDAE	500168	TEREBELLIDAE	
5001680201	EUPOLYMNIA HETEROBRA	5001680201	EUPOLYMNIA HETEROBRANCHIA	
50016806	NICOLEA	50016806	NICOLEA	
5001680601	NICOLEA ZOSTERICOLA	50016806	NICOLEA	
50016807	PISTA	50016807	PISTA	
5001680701	PISTA CRISTATA	5001680701	PISTA CRISTATA	
5001680702	PISTA FASCIATA	5001680702	PISTA FASCIATA	
50016808	POLYCIRRUS	50016808	POLYCIRRUS	¦+
5001680803	POLYCIRRUS KERGUELEN	50016808	POLYCIRRUS	¦
5001680898	NAME NOT FOUND	50016808	POLYCIRRUS	¦
5001680899	NAME NOT FOUND	50016808	POLYCIRRUS	¦
50016810	THELEPUS	50016810	THELEPUS	
5001681001	THELEPUS CRISPUS	5001681001	THELEPUS CRISPUS	
5001681002	THELEPUS HAMATUS	5001681002	THELEPUS HAMATUS	
5001681101	ARTACAMA CONIFERI	5001681101	ARTACAMA CONIFERI	
5001681702	PROCLEA GRAFFII	5001681702	PROCLEA GRAFFII	
5001690101	TEREBELLIDES STROEMI	5001690101	TEREBELLIDES STROEMII	+
500170	SABELLIDAE	500170	SABELLIDAE	
50017001	CHONE	50017001	CHONE	¦+
5001700101	CHONE GRACILIS	5001700101	CHONE GRACILIS	¦
5001700102	CHONE INFUNDIBULIFOR	5001700102	CHONE INFUNDIBULIFORMIS	¦
5001700104	CHONE DUNERI	5001700104	CHONE DUNERI	¦
5001700105	CHONE ECAUDATA	5001700105	CHONE ECAUDATA	¦
5001700199	NAME NOT FOUND	50017001	CHONE	¦
5001700201	EUCHONE ANALIS	5001700201	EUCHONE ANALIS	
5001700301	EUDISTYLIA POLYMORPH	5001700301	EUDISTYLIA POLYMORPHA	
5001700303	EUDISTYLIA VANCOUVER	5001700303	EUDISTYLIA VANCOUVERI	
50017006	POTAMILLA	50017006	POTAMILLA	
5001700601	POTAMILLA NEGLECTA	5001700601	POTAMILLA NEGLECTA	
5001700602	POTAMILLA MYRIOPS	5001700602	POTAMILLA MYRIOPS	
5001700698	NAME NOT FOUND	50017006	POTAMILLA	
5001700699	NAME NOT FOUND	50017006	POTAMILLA	
50017007	PSEUDOPOTAMILLA	50017007	PSEUDOPOTAMILLA	
5001700702	PSEUDOPOTAMILLA OCCE	5001700702	PSEUDOPOTAMILLA OCCELATA	
5001700703	PSEUDOPOTAMILLA RENI	5001700703	PSEUDOPOTAMILLA RENIFORMIS	
5001700801	SABELLA CRASSICORNIS	5001700801	SABELLA CRASSICORNIS	
5001700802	SABELLA MEDIA	5001700802	SABELLA MEDIA	
5001700902	SCHIZOBRANCHIA INSIG	5001700902	SCHIZOBRANCHIA INSIGNIS	
5001701002	BISPIRA RUGOSA	5001701002	BISPIRA RUGOSA	
5001701301	FABRICIA SABELLA	5001701301	FABRICIA SABELLA	
5001701302	FABRICIA MINUTA	5001701302	FABRICIA MINUTA	
5001701303	FABRICIA PACIFICA	5001701303	FABRICIA PACIFICA	
50017014	LAONOME	50017014	LAONOME	

(continued)

TABLE B-3 (continued)

5001701401	LAONOME KROYERI	50017014	LAONOME	
50017017	JASMINEIRA	50017017	JASMINEIRA	
50017099	NAME NOT FOUND	500170	SABELLIDAE	
500173	SERPULIDAE	500173	SERPULIDAE	
50017301	CHITINOPOMA	50017301	CHITINOPOMA	
5001730101	CHITINOPOMA OCCIDENT	50017301	CHITINOPOMA	
5001730202	CRUCIGERA ZYGOPHORA	5001730202	CRUCIGERA ZYGOPHORA	
5001730401	SERPULA VERMICULARIS	5001730401	SERPULA VERMICULARIS	
50017305	SPIRORBIS	50017305	SPIRORBIS	
5001730501	SPIRORBIS QUADRANGUL	50017305	SPIRORBIS	
5001730510	SPIRORBIS NAKAMURAI	50017305	SPIRORBIS	
5001730598	NAME NOT FOUND	50017305	SPIRORBIS	
5001730599	NAME NOT FOUND	50017305	SPIRORBIS	
5001730602	DEXIOSPIRA SPIRILLUM	5001730602	DEXIOSPIRA SPIRILLUM	
5002	ARCHIANNELIDA	5002	ARCHIANNELIDA	
500202	PROTODRILIDAE	500202	PROTODRILIDAE	
5002020101	PROTODRILUS FLABELLI	500202	PROTODRILIDAE	
500204	SACCOCIRRIDAE	500204	SACCOCIRRIDAE	
50020401	SACCOCIRRUS	500204	SACCOCIRRIDAE	
5002040101	SACCOCIRRUS EROTICUS	500204	SACCOCIRRIDAE	
500205	POLYGORDIIDAE	500205	POLYGORDIIDAE	
50020501	POLYGORDIUS	500205	POLYGORDIIDAE	
5004	OLIGOCHAETA	5004	OLIGOCHAETA	
500901	ENCHYTRAEIDAE	500901	ENCHYTRAEIDAE	
5012	HIRUDINEA	5012	HIRUDINEA	
51	GASTROPODA	51	GASTROPODA	
5102030101	HALIOTIS KAMTSCHATKA	5102030101	HALIOTIS KAMTSCHATKANA	
5102040204	PUNCTURELLA CUCULLAT	5102040204	PUNCTURELLA CUCULLATA	
5102040401	DIODORA ASPERA	5102040401	DIODORA ASPERA	
510205	ACMAEIDAE	510205	ACMAEIDAE	
5102050103	ACMAEA MITRA	5102050103	ACMAEA MITRA	+
5102050106	ACMAEA ROSACEA	5102050106	ACMAEA ROSACEA	
51020502	COLLISELLA	51020502	COLLISELLA	
5102050201	COLLISELLA PELTA	5102050201	COLLISELLA PELTA	
5102050202	COLLISELLA DIGITALIS	5102050202	COLLISELLA DIGITALIS	
5102050203	COLLISELLA OCHRACEA	5102050203	COLLISELLA OCHRACEA	
5102050301	NOTOACMAEA SCUTUM	5102050301	NOTOACMAEA SCUTUM	
5102070101	CRYPTOBRANCHIA CONCE	5102070101	CRYPTOBRANCHIA CONCENTRICA	
51021001	CALLIOSTOMA	51021001	CALLIOSTOMA	
5102100103	CALLIOSTOMA LIGATUM	51021001	CALLIOSTOMA	
51021003	MARGARITES/LIRULARIA	51021003	MARGARITES/LIRULARIA	
5102100302	MARGARITES HELICINUS	5102100302	MARGARITES HELICINUS	
5102100308	MARGARITES PUPILLUS	5102100308	MARGARITES PUPILLUS	*
5102100310	MARGARITES LIRULATUS	5102100310	MARGARITES LIRULATUS	*
5102100402	SOLARIELLA OBSCURA	5102100402	SOLARIELLA OBSCURA	
51021005	TEGULA	51021005	TEGULA	
5102120201	MOELLERIA QUADRAE	5102120201	MOELLERIA QUADRAE	
51030903	LACUNA	51030903	LACUNA	

(continued)

TABLE B-3 (continued)

5103090301	LACUNA CARININATA	5103090301	LACUNA CARININATA	
5103090302	LACUNA VARIEGATA	5103090302	LACUNA VARIEGATA	*
5103100101	LITTORINA SITKANA	5103100101	LITTORINA SITKANA	
5103100104	LITTORINA SCUTULATA	5103100104	LITTORINA SCUTULATA	
51032001	ALVINIA	51032001	ALVINIA	+
51032004	BARLEEIA	51032004	BARLEEIA	
5103230202	VITRINELLA COLUMBIAN	5103230202	VITRINELLA COLUMBIANA	
51034601	BITTIUM	51034601	BITTIUM	
5103460103	BITTIUM ESCHRICHTII	51034601	BITTIUM	
51034602	CERITHIOPSIS	51034602	CERITHIOPSIS	
5103460203	CERITHIOPSIS STEPHAN	51034602	CERITHIOPSIS	
5103530199	NAME NOT FOUND	51035301	MELANELLA	
51036202	TRICHOTROPIS	51036202	TRICHOTROPIS	
5103620204	TRICHOTROPIS CANCELL	51036202	TRICHOTROPIS	
510364	CALYPTRAEIDAE	510364	CALYPTRAEIDAE	
5103640101	CALYPTRAEA FASTIGATA	5103640101	CALYPTRAEA FASTIGATA	*
51036402	CREPIDULA	51036402	CREPIDULA	
5103640201	CREPIDULA NUMMARIA	5103640201	CREPIDULA NUMMARIA	
5103640203	CREPIDULA ADUNCA	5103640203	CREPIDULA ADUNCA	
5103640298	NAME NOT FOUND	51036402	CREPIDULA	
5103640299	NAME NOT FOUND	51036402	CREPIDULA	
5103640301	CREPIPATELLA LINGULA	5103640301	CREPIPATELLA LINGULATA	
5103660409	VELUTINA LAEVIGATA	5103660409	VELUTINA LAEVIGATA	
5103660410	VELUTINA PROLONGATA	5103660410	VELUTINA PROLONGATA	
51037602	NATICA	51037602	NATICA	¦+
5103760201	NATICA ALEUTICA/CLAU	51037602	NATICA	¦
5103760402	POLINICES PALLIDA	5103760402	POLINICES PALLIDA	
5103760406	POLINICES LEWISII	5103760406	POLINICES LEWISII	
5103780101	FUSITRITON OREGONENS	5103780101	FUSITRITON OREGONENSIS	
5105010101	CERATOSTOMA FOLIATUM	5105010101	CERATOSTOMA FOLIATUM	
5105010205	OCENEBRA SCLERA	5105010205	OCENEBRA SCLERA	
5105010206	OCENEBRA LURIDA	5105010206	OCENEBRA LURIDA	
5105010417	TROPHONOPSIS ORPHEUS	5105010417	TROPHONOPSIS ORPHEUS	
51050105	NUCELLA	51050105	NUCELLA	
5105010501	NUCELLA CANALICULATA	5105010501	NUCELLA CANALICULATA	
5105010502	NUCELLA LAMELLOSA	5105010502	NUCELLA LAMELLOSA	
5105010503	NUCELLA EMARGINATA	5105010503	NUCELLA EMARGINATA	
510503	PYRENIDAE	510503	PYRENIDAE	
5105030101	AMPHISSA COLUMBIANA	5105030101	AMPHISSA COLUMBIANA	*
5105030102	AMPHISSA RETICULATA	5105030102	AMPHISSA RETICULATA	
5105030191	NAME NOT FOUND	51050301	AMPHISSA	
51050302	MITRELLA	51050302	MITRELLA	¦+
5105030202	MITRELLA TUBEROSA	5105030202	MITRELLA TUBEROSA	¦
5105030204	MITRELLA GOULDI	5105030204	MITRELLA GOULDI	¦
5105030206	MITRELLA CARINATA	5105030206	MITRELLA CARINATA	¦
5105040201	SEARLESIA DIRA	5105040201	SEARLESIA DIRA	
51050506	MOHNIA	51050506	MOHNIA	
51050509	PLICIFUSUS	51050509	PLICIFUSUS	

(continued)

TABLE B-3 (continued)

51050801	NASSA	51050801	NASSA		
5105080101	NASSARIUS MENDICUS	51050801	NASSA		
5105150101	GRANULINA MARGARITUL	5105150101	GRANULINA MARGARITULA		
510602	TURRIDAE	510602	TURRIDAE		
5106020405	OENOPOTA TABULATA	510602	TURRIDAE		
510801	PYRAMIDELLIDAE	510801	PYRAMIDELLIDAE		
51080101	ODOSTOMIA	51080101	ODOSTOMIA		+
51080102	TURBONILLA	51080102	TURBONILLA	|	+
5108010201	TURBONILLA TORQUATA	51080102	TURBONILLA	|	
5110	CEPHALASPIDEA	5110	CEPHALASPIDEA		
51100401	ACTEOCINA	51100401	ACTEOCINA		
51100402	CYLICHNA	51100402	CYLICHNA		
5110060101	AGLAJA DIOMEDEUM	5110060101	AGLAJA DIOMEDEUM		
51100701	GASTROPTERON	51100701	GASTROPTERON		
5110070101	GASTROPTERON PACIFIC	51100701	GASTROPTERON		
51100901	DIAPHANA	51100901	DIAPHANA		
5110120101	HAMINOEA VESICULA	5110120101	HAMINOEA VESICULA		
5110120103	HAMINOEA VIRESCENS	5110120103	HAMINOEA VIRESCENS		
51101301	RETUSA	51101301	RETUSA		
5124020101	PHYLLAPLYSIA TAYLORI	5124020101	PHYLLAPLYSIA TAYLORI		
5127	NUDIBRANCHIA	5127	NUDIBRANCHIA		
5130020301	DIAULULA SANDIEGENSI	5130020301	DIAULULA SANDIEGENSIS		
51300303	ARCHIDORIS	51300303	ARCHIDORIS		
5131	NUDIBRANCHIA DORIDOI	5131	NUDIBRANCHIA DORIDOIDEA PHANEROB		
51340601	DENDRONOTUS	51340601	DENDRONOTUS		
5134060103	DENDRONOTUS FRONDOSU	51340601	DENDRONOTUS		
51340901	DOTO	51340901	DOTO		
5139	NUDIBRANCHIA EOLIDOI	5139	NUDIBRANCHIA EOLIDOIDEA		
51410101	EUBRANCHUS	51410101	EUBRANCHUS		
514203	AEOLIDIIDAE	514203	AEOLIDIIDAE		
5143010101	ONCHIDELLA BOREALIS	5143010101	ONCHIDELLA BOREALIS		
53	POLYPLACOPHORA	53	POLYPLACOPHORA		
5302010199	NAME NOT FOUND	53020101	LEPTOCHITON		
5302020101	HANLEYA HANLEYI	5302020101	HANLEYA HANLEYI		
5303	NEOLORICATA ISCHNOCH	5303	NEOLORICATA ISCHNOCHITONINA		
530302	ISCHNOCHITONIDAE	530302	ISCHNOCHITONIDAE		
5303020102	BASILIOCHITON HEATHI	5303020102	BASILIOCHITON HEATHII		
5303020201	CYANOPLAX DENTIENS	5303020201	CYANOPLAX DENTIENS		
53030203	ISCHNOCHITON	53030203	ISCHNOCHITON		
5303020303	ISCHNOCHITON INTERST	5303020303	ISCHNOCHITON INTERSTINCTUS		
5303020309	ISCHNOCHITON RETIPOR	5303020309	ISCHNOCHITON RETIPOROSUS		
53030206	TONICELLA	53030206	TONICELLA		
5303020601	TONICELLA INSIGNIS	5303020601	TONICELLA INSIGNIS		
5303020602	TONICELLA LINEATA	5303020602	TONICELLA LINEATA		*
5303020603	TONICELLA MARMOREA	5303020603	TONICELLA MARMOREA		
5303020701	LEPIDOZONA MERTENSII	5303020701	LEPIDOZONA MERTENSII		+
5303020703	LEPIDOZONA COOPERI	5303020703	LEPIDOZONA COOPERI		
5303020801	STENOPLAX FALLAX	5303020801	STENOPLAX FALLAX		

(continued)

TABLE B-3 (continued)

5303060102	CHAETOPLEURA GEMMA	5303060102	CHAETOPLEURA GEMMA	
5303070301	KATHARINA TUNICATA	5303070301	KATHARINA TUNICATA	
53030704	MOPALIA	53030704	MOPALIA	
5303070401	MOPALIA CILIATA	5303070401	MOPALIA CILIATA	
5303070402	MOPALIA CIRRATA	5303070402	MOPALIA CIRRATA	
5303070407	MOPALIA LIGNOSA	5303070407	MOPALIA LIGNOSA	
5303070408	MOPALIA MUCOSA	5303070408	MOPALIA MUCOSA	
5303070498	NAME NOT FOUND	53030704	MOPALIA	
5303070499	NAME NOT FOUND	53030704	MOPALIA	
55	BIVALVIA	55	BIVALVIA	
5502020101	ACILA CASTRENIS	5502020101	ACILA CASTRENIS	
5502020201	NUCULA TENUIS	5502020201	NUCULA TENUIS	*
5502040202	NUCULANA MINUTA	5502040202	NUCULANA MINUTA	
5502040212	NUCULANA HAMATA	5502040212	NUCULANA HAMATA	+
5502040298	NAME NOT FOUND	55020402	NUCULANA	
55020405	YOLDIA	55020405	YOLDIA	
5502040503	YOLDIA MYALIS	5502040503	YOLDIA MYALIS	
5502040504	YOLDIA SCISSURATA	5502040504	YOLDIA SCISSURATA	
55060601	GLYCYMERIS	55060601	GLYCYMERIS	¦*
5506060101	GLYCYMERIS SUBOBSOLE	5506060101	GLYCYMERIS SUBOBSOLETA	¦
5506060104	GLYCYMERIS SEPTENTRI	5506060104	GLYCYMERIS SEPTENTRIONALIS	¦
55070101	MYTILUS	55070101	MYTILUS	
5507010101	MYTILUS EDULIS	55070101	MYTILUS	
5507010201	CRENELLA DECUSSATA	5507010201	CRENELLA DECUSSATA	+
55070104	MUSCULUS	55070104	MUSCULUS	
5507010401	MUSCULUS NIGER	5507010401	MUSCULUS NIGER	
5507010402	MUSCULUS DISCORS	5507010402	MUSCULUS DISCORS	
55070106	MODIOLUS	55070106	MODIOLUS	¦+
5507010603	MODIOLUS RECTUS	55070106	MODIOLUS	¦
5507010699	NAME NOT FOUND	55070106	MODIOLUS	¦
5509050101	CHLAMYS HASTATA	5509050101	CHLAMYS HASTATA	
5509050401	PECTEN CAURINUS	5509050401	PECTEN CAURINUS	
5509090101	PODODESMUS MACROCHIS	5509090101	PODODESMUS MACROCHISMA	
5509090103	PODODESMUS CEPIO	5509090103	PODODESMUS CEPIO	
5515	VENEROIDA	5515	VENEROIDA	
55150101	PARVILUCINA	55150101	PARVILUCINA	¦+
5515010101	PARVILUCINA TENUISCU	55150101	PARVILUCINA	¦
55150102	LUCINOMA	55150102	LUCINOMA	
55150103	LUCINA	55150103	LUCINA	
5515020201	AXINOPSIDA SERRICATA	5515020201	AXINOPSIDA SERRICATA	
5515070101	LASAEA CISTULA	5515070101	LASAEA CISTULA	
5515100102	MYSELLA TUMIDA	5515100102	MYSELLA TUMIDA	*
551517	CARDITIDAE	551517	CARDITIDAE	
55151701	CYCLOCARDIA	55151701	CYCLOCARDIA	
5515170101	CYCLOCARDIA VENTRICO	5515170101	CYCLOCARDIA VENTRICOSA	
5515170102	CYCLOCARDIA CREBRICO	5515170102	CYCLOCARDIA CREBRICOSTATA	
5515170103	CYCLOCARDIA UMNAKA	5515170103	CYCLOCARDIA UMNAKA	
5515170105	CYCLOCARDIA CRASSIDE	5515170105	CYCLOCARDIA CRASSIDENS	

(continued)

TABLE B-3 (continued)

5515170201	MIONTODISCUS PROLONG	5515170201	MIONTODISCUS PROLONGATUS	
5515170402	CARDITA VENTRICOSA	5515170402	CARDITA VENTRICOSA	
5515190102	ASTARTE ALASKENSIS	5515190102	ASTARTE ALASKENSIS	
5515190105	ASTARTE COMPACTA	5515190105	ASTARTE COMPACTA	
551522	CARDIIDAE	551522	CARDIIDAE	
55152201	CLINOCARDIUM	55152201	CLINOCARDIUM	¦+
5515220101	CLINOCARDIUM CILIATU	5515220101	CLINOCARDIUM CILIATUM	¦
5515220102	CLINOCARDIUM NUTTALL	5515220102	CLINOCARDIUM NUTTALLII	¦
5515220104	CLINOCARDIUM CALIFOR	5515220104	CLINOCARDIUM CALIFORNIENSE	¦
5515220301	NEMOCARDIUM CENTIFOL	5515220301	NEMOCARDIUM CENTIFOLIUM	
55152298	NAME NOT FOUND	551522	CARDIIDAE	
5515229999	NAME NOT FOUND	551522	CARDIIDAE	
55152501	SPISULA	55152501	SPISULA	
5515250201	TRESUS CAPAX	5515250201	TRESUS CAPAX	
551529	SOLENIDAE	551529	SOLENIDAE	
55152902	SOLEN	551529	SOLENIDAE	
5515290201	SOLEN SICARIUS	551529	SOLENIDAE	
55153101	MACOMA	55153101	MACOMA	¦+
5515310101	MACOMA CALCAREA	5515310101	MACOMA CALCAREA	¦
5515310102	MACOMA ELIMATA	5515310102	MACOMA ELIMATA	¦
5515310106	MACOMA OBLIQUA	5515310106	MACOMA OBLIQUA	¦
5515310107	MACOMA MOESTA	5515310107	MACOMA MOESTA	¦
5515310108	MACOMA CRASSULA	5515310108	MACOMA CRASSULA	¦
5515310111	MACOMA YOLDIFORMIS	5515310111	MACOMA YOLDIFORMIS	¦
5515310112	MACOMA CARLOTTENSIS	5515310112	MACOMA CARLOTTENSIS	¦
5515310114	MACOMA NASUTA	5515310114	MACOMA NASUTA	¦
5515310115	MACOMA INQUINATA	5515310115	MACOMA INQUINATA	¦
5515310116	MACOMA BALTHICA	5515310116	MACOMA BALTHICA	¦
5515310117	MACOMA SECTA	5515310117	MACOMA SECTA	¦
55153102	TELLINA	55153102	TELLINA	¦+
5515310203	TELLINA CARPENTERI	5515310203	TELLINA CARPENTERI	¦
5515310204	TELLINA MODESTA	5515310204	TELLINA MODESTA	¦
5515350101	SEMELE RUBROPICTA	5515350101	SEMELE RUBROPICTA	
55154701	TRANSENNELLA	55154701	TRANSENNELLA	¦+
5515470101	TRANSENNELLA TANTILL	55154701	TRANSENNELLA	¦
5515470201	SAXIDOMUS GIGANTEA	5515470201	SAXIDOMUS GIGANTEA	
5515470301	COMPSOMYAX SUBDIAPHA	5515470301	COMPSOMYAX SUBDIAPHANA	
5515470501	PSEPHIDIA LORDI	5515470501	PSEPHIDIA LORDI	*
5515470601	HUMILARIA KENNERLYI	5515470601	HUMILARIA KENNERLYI	
55154707	PROTOTHACA	55154707	PROTOTHACA	
5515470701	PROTOTHACA STAMINEA	5515470701	PROTOTHACA STAMINEA	*
5515470702	PROTOTHACA TENERRIMA	5515470702	PROTOTHACA TENERRIMA	
5515470801	TAPES PHILIPPINARUM	5515470801	TAPES PHILIPPINARUM	
5517010101	CRYPTOMYA CALIFORNIC	5517010101	CRYPTOMYA CALIFORNICA	
55170102	MYA	55170102	MYA	
5517010201	MYA ARENARIA	5517010201	MYA ARENARIA	+
5517010203	MYA TRUNCATA	5517010203	MYA TRUNCATA	
5517010205	MYA ELEGANS	5517010205	MYA ELEGANS	

(continued)

TABLE B-3 (continued)

5517060201	HIATELLA ARCTICA	5517060201	HIATELLA ARCTICA	
5517060401	PANOPEA GENEROSA	5517060401	PANOPEA GENEROSA	
5518010101	ZIRFAEA PILSBURYI	5518010101	ZIRFAEA PILSBURYI	
5520020102	PANDORA FILOSA	5520020102	PANDORA FILOSA	
5520050101	ENTODESMA SAXICOLUM	5520050101	ENTODESMA SAXICOLUM	
5520050202	LYONSIA CALIFORNICA	5520050202	LYONSIA CALIFORNICA	
5520050301	MYTILIMERIA NUTTALLI	5520050301	MYTILIMERIA NUTTALLII	
5520100103	CARDIOMYA OLDROYDI	5520100103	CARDIOMYA OLDROYDI	
56	SCAPHOPODA	56	SCAPHOPODA	
6001	PANTOPODA	6001	PANTOPODA	
600101	NYMPHONIDAE	600101	NYMPHONIDAE	
6001010199	NAME NOT FOUND	600101	NYMPHONIDAE	
6001040201	ACHELIA CHELATA	6001040201	ACHELIA CHELATA	
6001040204	ACHELIA NUDIUSCULA	6001040204	ACHELIA NUDIUSCULA	
60010403	AMMOTHELLA	60010403	AMMOTHELLA	
6001060102	PHOXICHILIDIUM FEMOR	6001060102	PHOXICHILIDIUM FEMORATUM	
60010602	ANOPLODACTYLUS	60010602	ANOPLODACTYLUS	
6001060302	HALOSOMA COMPACTUM	6001060302	HALOSOMA COMPACTUM	
61	ARTHROPODA MANDIBULA	61	ARTHROPODA MANDIBULATA CRUSTACEA	
6110	OSTRACODA	6110	OSTRACODA	
6117	COPEPODA	6117	COPEPODA	
6118	COPEPODA CALANOIDA	6118	COPEPODA CALANOIDA	
611801	CALANIDAE	6118	COPEPODA CALANOIDA	
6119	COPEPODA HARPACTICOI	6119	COPEPODA HARPACTICOIDA	
6120	COPEPODA CYCLOPOIDA	6120	COPEPODA CYCLOPOIDA	
612008	CYCLOPIDAE	6120	COPEPODA CYCLOPOIDA	
61340201	BALANUS	61340201	BALANUS	
6134020102	BALANUS BALANUS	6134020102	BALANUS BALANUS	
6134020103	BALANUS CARIOSUS	6134020103	BALANUS CARIOSUS	
6134020104	BALANUS CRENATUS	6134020104	BALANUS CRENATUS	
6134020107	BALANUS GLANDULA	6134020107	BALANUS GLANDULA	
6134020110	BALANUS NUBILIS	6134020110	BALANUS NUBILIS	
6134020111	BALANUS ROSTRATUS	6134020111	BALANUS ROSTRATUS	
61450101	NEBALIA	61450101	NEBALIA	|+
6145010102	NEBALIA PUGETTENSIS	61450101	NEBALIA	|
6151	PERACARIDA MYSIDACEA	6151	PERACARIDA MYSIDACEA	
61530101	ACANTHOMYSIS	61530101	ACANTHOMYSIS	
6153010102	ACANTHOMYSIS DAVISI	6153010102	ACANTHOMYSIS DAVISI	
6153010107	ACANTHOMYSIS SCULPTA	6153010107	ACANTHOMYSIS SCULPTA	
6153010301	ARCHAEOMYSIS GREBNIT	6153010301	ARCHAEOMYSIS GREBNITZKII	
6153010901	HOLMESIELLA ANOMALA	6153010901	HOLMESIELLA ANOMALA	
6153011403	MYSIS OCULATA	6153011403	MYSIS OCULATA	
6153011509	NEOMYSIS INTEGER	6153011509	NEOMYSIS INTEGER	
6154	PERACARIDA CUMACEA	6154	PERACARIDA CUMACEA	
615401	LAMPROPIDAE	615401	LAMPROPIDAE	
61540101	LAMPROPS	61540101	LAMPROPS	
6154010103	LAMPROPS FASCIATA	6154010103	LAMPROPS FASCIATA	
6154010104	LAMPROPS CARINATA	6154010104	LAMPROPS CARINATA	

(continued)

TABLE B-3 (continued)

61540102	HEMILAMPROPS	61540102	HEMILAMPROPS	
61540402	EUDORELLA	61540402	EUDORELLA	
61540403	EUDORELLOPSIS	61540403	EUDORELLOPSIS	
61540501	DIASTYLIS	61540501	DIASTYLIS	*
61540502	DIASTYLOPSIS	61540502	DIASTYLOPSIS	|+
6154050202	DIASTYLOPSIS TENUIS	61540502	DIASTYLOPSIS	|
6154050299	NAME NOT FOUND	61540502	DIASTYLOPSIS	|
61540504	LEPTOSTYLIS	61540504	LEPTOSTYLIS	
61540505	COLUROSTYLIS	61540505	COLUROSTYLIS	
61540508	OXYUROSTYLIS	61540508	OXYUROSTYLIS	
61540701	CAMPYLASPIS	61540701	CAMPYLASPIS	
61540801	CUMELLA	61540801	CUMELLA	|+
6154080102	CUMELLA VULGARIS	61540801	CUMELLA	|
615409	BODOTRIIDAE	615409	BODOTRIIDAE	
61540903	LEPTOCUMA/PSEUDOLEPT	615409	BODOTRIIDAE	
6157	PERACARIDA TANAIDACE	6157	PERACARIDA TANAIDACEA DIKONOPHOR	
615701	TANAIDAE	615701	TANAIDAE	
6157010301	ANATANAIS NORMANI	6157010301	ANATANAIS NORMANI	
6157010401	PANCOLUS CALIFORNIEN	6157010401	PANCOLUS CALIFORNIENSIS	
615702	PARATANAIDAE	615702	PARATANAIDAE	
61570201	LEPTOCHELIA (TANAI	61570201	LEPTOCHELIA (TANAIDACEA)	|*
6157020101	LEPTOCHELIA SAVIGNYI	6157020101	LEPTOCHELIA SAVIGNYI	|
6157020103	LEPTOCHELIA DUBIA	6157020103	LEPTOCHELIA DUBIA	|
6157020199	NAME NOT FOUND	61570201	LEPTOCHELIA (TANAIDACEA)	|
6158	PERACARIDA ISOPODA	6158	PERACARIDA ISOPODA	
616001	ANTHURIDAE	616001	ANTHURIDAE	
6160010299	NAME NOT FOUND	616001	ANTHURIDAE	
6160010501	PARANTHURA ELEGANS	616001	ANTHURIDAE	
6160019999	NAME NOT FOUND	616001	ANTHURIDAE	
6161	PERACARIDA ISOPODA F	6161	PERACARIDA ISOPODA FLABELLIFERA	
6161010102	CIROLANA HARFORDI	6161010102	CIROLANA HARFORDI	
6161010107	CIROLANA VANCOUVEREN	6161010107	CIROLANA VANCOUVERENSIS	
616102	SPHAEROMATIDAE	616102	SPHAEROMATIDAE	
61610201	TECTICEPS	61610201	TECTICEPS	
6161020301	GNORIMOSPHAEROMA ORE	6161020301	GNORIMOSPHAEROMA OREGONENSIS	
61610204	EXOSPHAEROMA	61610204	EXOSPHAEROMA	
6161020401	EXOSPHAEROMA AMPLICA	6161020401	EXOSPHAEROMA AMPLICAUDA	+
6161020402	EXOSPHAEROMA MEDIA	6161020402	EXOSPHAEROMA MEDIA	
6161020403	EXOSPHAEROMA RHOMBUR	6161020403	EXOSPHAEROMA RHOMBURUM	
6161020501	DYNAMENELLA SHEARERI	6161020501	DYNAMENELLA SHEARERI	
6161020502	DYNAMENELLA GLABRA	6161020502	DYNAMENELLA GLABRA	
6161020503	DYNAMENELLA DILATATA	6161020503	DYNAMENELLA DILATATA	
6161050102	LIMNORIA ALGARUM	6161050102	LIMNORIA ALGARUM	
6161070101	AEGA SYMMETRICA	6161070101	AEGA SYMMETRICA	
61610702	ROCINELA	61610702	ROCINELA	
6162	PERACARIDA ISOPODA V	6162	PERACARIDA ISOPODA VALVIFERA	
61620202	SYNIDOTEA	61620202	SYNIDOTEA	
6162020201	SYNIDOTEA BICUSPIDA	6162020201	SYNIDOTEA BICUSPIDA	+

(continued)

TABLE B-3 (continued)

6162020205	SYNIDOTEA NODULOSA	6162020205	SYNIDOTEA NODULOSA	
6162020209	SYNIDOTEA PETTIBONEA	6162020209	SYNIDOTEA PETTIBONEAE	
61620203	IDOTEA	61620203	IDOTEA	|+
6162020301	IDOTEA RESECATA	6162020301	IDOTEA RESECATA	|
6162020302	IDOTEA WOSNESENSKII	6162020302	IDOTEA WOSNESENSKII	|
6162020303	IDOTEA FEWKESI	6162020303	IDOTEA FEWKESI	|
6162020304	IDOTEA RUFESCENS	6162020304	IDOTEA RUFESCENS	|
6162020305	IDOTEA OCHOTENSIS	6162020305	IDOTEA OCHOTENSIS	|
6162020307	IDOTEA ACULEATA	6162020307	IDOTEA ACULEATA	|
6162020312	IDOTEA SCHMITTI	6162020312	IDOTEA SCHMITTI	|
6162020313	IDOTEA MONTEREYENSIS	6162020313	IDOTEA MONTEREYENSIS	|
6162020799	NAME NOT FOUND	61620207	EDOTEA	
616302	ASELLIDAE	616302	ASELLIDAE	
61630201	IANIROPSIS	61630201	IANIROPSIS	
6163020101	IANIROPSIS KINCAIDI	6163020101	IANIROPSIS KINCAIDI	+
6163020102	IANIROPSIS PUGETTENS	6163020102	IANIROPSIS PUGETTENSIS	
6163020103	IANIROPSIS ANALOGA	6163020103	IANIROPSIS ANALOGA	
6163020106	IANIROPSIS TRIDENS	6163020106	IANIROPSIS TRIDENS	
6163020198	NAME NOT FOUND	61630201	IANIROPSIS	
6163020199	NAME NOT FOUND	61630201	IANIROPSIS	
6163020306	JANIRALATA OCCIDENTA	6163020306	JANIRALATA OCCIDENTALIS	
61631101	JAEROPSIS	61631101	JAEROPSIS	
6163110101	JAEROPSIS LOBATA	6163110101	JAEROPSIS LOBATA	
6163110102	JAEROPSIS SETOSA	6163110102	JAEROPSIS SETOSA	
6163110103	JAEROPSIS DUBIA	6163110103	JAEROPSIS DUBIA	
6163110199	NAME NOT FOUND	61631101	JAEROPSIS	
61631201	MUNNA	61631201	MUNNA	
6163120101	MUNNA STEPHENSENI	6163120101	MUNNA STEPHENSENI	
6163120102	MUNNA CHROMATOCEPHAL	6163120102	MUNNA CHROMATOCEPHALA	
6163120103	MUNNA UBIQUITA	6163120103	MUNNA UBIQUITA	
6163129999	NAME NOT FOUND	616312	MUNNIDAE	
616504	BOPYRIDAE	616504	BOPYRIDAE	
6165040201	ARGEIA PUGETTENSIS	6165040201	ARGEIA PUGETTENSIS	
6165040701	PHYLLODURUS ABDOMINA	6165040701	PHYLLODURUS ABDOMINALIS	
6169	PERACARIDA AMPHIPODA	6169	GAMMARID AMPHIPOD	
6169010399	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
61690201	AMPELISCA	61690201	AMPELISCA	|+
6169020101	AMPELISCA MACROCEPHA	61690201	AMPELISCA	|
6169020111	AMPELISCA AGASSIZI	61690201	AMPELISCA	|
6169020112	AMPELISCA CRISTATA	61690201	AMPELISCA	|
6169020114	AMPELISCA PUGETICA	61690201	AMPELISCA	|
6169020197	NAME NOT FOUND	61690201	AMPELISCA	|
6169020198	NAME NOT FOUND	61690201	AMPELISCA	|
6169020199	NAME NOT FOUND	61690201	AMPELISCA	|
6169020203	BYBLIS SERRATA	61690202	BYBLIS	
6169020299	NAME NOT FOUND	61690202	BYBLIS	
6169030202	NAME NOT FOUND	61690302	AMPHILOCHUS	
6169030299	NAME NOT FOUND	61690302	AMPHILOCHUS	

(continued)

TABLE B-3 (continued)

61690401	AMPHITHOE	61690401	AMPHITHOE	¦+
6169040104	AMPHITHOE SIMULANS	61690401	AMPHITHOE	¦
6169040116	AMPHITHOE VALIDA	61690401	AMPHITHOE	¦
6169040117	AMPHITHOE HUMERALIS	61690401	AMPHITHOE	¦
6169040118	AMPHITHOE LACERTOSA	61690401	AMPHITHOE	¦
6169040196	NAME NOT FOUND	61690401	AMPHITHOE	¦
6169040197	NAME NOT FOUND	61690401	AMPHITHOE	¦
6169040198	NAME NOT FOUND	61690401	AMPHITHOE	¦
6169040199	NAME NOT FOUND	61690401	AMPHITHOE	¦
6169060202	AOROIDES COLUMBIAE	6169060202	AOROIDES COLUMBIAE	*
6169070101	ARGISSA HAMATIPES	6169070101	ARGISSA HAMATIPES	
61690901	ATYLUS	61690901	ATYLUS	
6169090101	ATYLUS TRIDENS	61690901	ATYLUS	
6169090105	ATYLUS COLLINGI	61690901	ATYLUS	
6169090108	ATYLUS LEVIDENSUS	61690901	ATYLUS	
6169090199	NAME NOT FOUND	61690901	ATYLUS	
61691202	CALLIOPIUS	61691202	CALLIOPIUS	
6169120901	OLIGOCHINUS LIGHTI	6169120901	OLIGOCHINUS LIGHTI	
6169121001	CALLIOPIELLA PRATTI	6169121001	CALLIOPIELLA PRATTI	
61691502	COROPHIUM	61691502	COROPHIUM	¦+
6169150203	COROPHIUM CRASSICORN	61691502	COROPHIUM	¦
6169150302	ERICTHONIUS BRASILIE	6169150302	ERICTHONIUS BRASILIENSIS	
616917	DEXAMINIDAE	616917	DEXAMINIDAE	
6169170299	NAME NOT FOUND	616917	DEXAMINIDAE	
6169170301	POLYCHERIA OSBORNI	616917	DEXAMINIDAE	
616920	EUSIRIDAE	616920	EUSIRIDAE	
6169200199	NAME NOT FOUND	616920	EUSIRIDAE	
6169201003	PARAMOERA MOHRI	6169201003	PARAMOERA MOHRI	
61692012	PONTOGENEIA	61692012	PONTOGENEIA	¦+
6169201203	PONTOGENEIA INERMIS	61692012	PONTOGENEIA	¦
6169201208	PONTOGENEIA ROSTRATA	61692012	PONTOGENEIA	¦
6169201297	NAME NOT FOUND	61692012	PONTOGENEIA	¦
6169201299	NAME NOT FOUND	61692012	PONTOGENEIA	¦
616921	GAMMARIDAE	616921	GAMMARIDAE	
61692101	ANISOGAMMARUS	61692101	ANISOGAMMARUS	
6169210106	ANISOGAMMARUS PUGETT	61692101	ANISOGAMMARUS	
6169210109	ANISOGAMMARUS CONFER	61692101	ANISOGAMMARUS	
61692102	CERADOCUS	61692102	CERADOCUS	
6169210202	CERADOCUS SPINICAUDU	61692102	CERADOCUS	
6169210299	NAME NOT FOUND	61692102	CERADOCUS	
6169210302	ELASMOPUS ANTENNATUS	6169210302	ELASMOPUS ANTENNATUS	
61692108	MAERA	61692108	MAERA	
6169210899	NAME NOT FOUND	61692108	MAERA	
61692109	MEGALUROPUS	61692109	MEGALUROPUS	
6169210999	NAME NOT FOUND	61692109	MEGALUROPUS	
61692110	MELITA (AMPHIPODA	61692110	MELITA (AMPHIPODA)	¦+
6169211003	MELITA DENTATA	61692110	MELITA (AMPHIPODA)	¦
6169211005	MELITA CALIFORNICA	61692110	MELITA (AMPHIPODA)	¦

(continued)

TABLE B-3 (continued)

6169211008	MELITA DESDICHADA	61692110	MELITA (AMPHIPODA)	¦
6169211099	NAME NOT FOUND	61692110	MELITA (AMPHIPODA)	¦
616922	HAUSTORIIDAE	616922	HAUSTORIIDAE	
61692201	EOHAUSTORIUS	61692201	EOHAUSTORIUS	
6169220101	EOHAUSTORIUS WASHING	61692201	EOHAUSTORIUS	
6169220199	NAME NOT FOUND	61692201	EOHAUSTORIUS	
61692202	PONTOPOREIA (AMPHI	61692202	PONTOPOREIA (AMPHIPODA)	
6169220201	PONTOPOREIA FEMORATA	61692202	PONTOPOREIA (AMPHIPODA)	
61692303	NAJNA	61692303	NAJNA	
6169230301	NAJNA CONSILIORUM	61692303	NAJNA	
6169240107	ALLORCHESTES ANCEPS	6169240107	ALLORCHESTES ANCEPS	
61692402	HYALE	61692402	HYALE	¦+
6169240201	HYALE RUBRA	61692402	HYALE	¦
6169240205	HYALE PUGETTENSIS	61692402	HYALE	¦
61692404	PARALLORCHESTES	61692404	PARALLORCHESTES	
6169240401	PARALLORCHESTES OCHO	61692404	PARALLORCHESTES	
616926	ISAEIDAE	616926	ISAEIDAE	
61692602	PHOTIS	61692602	PHOTIS	¦+
6169260201	PHOTIS BREVIPES	61692602	PHOTIS	¦
6169260205	PHOTIS FISCHMANNI	61692602	PHOTIS	¦
6169260207	PHOTIS DENTATA	61692602	PHOTIS	¦
6169260297	NAME NOT FOUND	61692602	PHOTIS	¦
6169260298	NAME NOT FOUND	61692602	PHOTIS	¦
6169260299	NAME NOT FOUND	61692602	PHOTIS	¦
61692603	PROTOMEDEIA	61692603	PROTOMEDEIA	¦+
6169260399	NAME NOT FOUND	61692603	PROTOMEDEIA	¦
61692604	GAMMAROPSIS	61692604	GAMMAROPSIS	¦+
6169260401	GAMMAROPSIS THOMPSON	61692604	GAMMAROPSIS	¦
6169260498	NAME NOT FOUND	61692604	GAMMAROPSIS	¦
6169260499	NAME NOT FOUND	61692604	GAMMAROPSIS	¦
6169260599	NAME NOT FOUND	616926	ISAEIDAE	
6169269999	NAME NOT FOUND	616926	ISAEIDAE	
61692702	ISCHYROCERUS	61692702	ISCHYROCERUS	¦+
6169270202	ISCHYROCERUS ANGUIPE	61692702	ISCHYROCERUS	¦
6169270302	JASSA FALCATA	6169270302	JASSA FALCATA	
6169279999	NAME NOT FOUND	616927	ISCHYROCERIDAE	
616934	LYSIANASSIDAE	616934	LYSIANASSIDAE	
61693403	ANONYX	61693403	ANONYX	
6169340302	ANONYX NUGAX	61693403	ANONYX	
6169340312	ANONYX LATICOXAE	61693403	ANONYX	
6169340397	NAME NOT FOUND	61693403	ANONYX	
6169340398	NAME NOT FOUND	61693403	ANONYX	
61693414	HIPPOMEDON	61693414	HIPPOMEDON	
6169341402	HIPPOMEDON DENTICULA	61693414	HIPPOMEDON	
6169341499	NAME NOT FOUND	61693414	HIPPOMEDON	
6169342199	NAME NOT FOUND	61693421	LEPIDEPECREUM	
61693422	LYSIANASSA	61693422	LYSIANASSA	
61693429	ORCHOMENE	61693429	ORCHOMENE	¦+

(continued)

TABLE B-3 (continued)

6169342902	ORCHOMENE NANA	61693429	ORCHOMENE	¦
6169342904	ORCHOMENE PINQUIS	61693429	ORCHOMENE	¦
6169342999	NAME NOT FOUND	61693429	ORCHOMENE	¦
6169349999	NAME NOT FOUND	616934	LYSIANASSIDAE	
6169370816	MONOCULODES ZERNOVI	61693708	MONOCULODES	
6169370899	NAME NOT FOUND	61693708	MONOCULODES	
61693714	SYNCHELIDIUM	61693714	SYNCHELIDIUM	¦*
6169371402	SYNCHELIDIUM SHOEMAK	61693714	SYNCHELIDIUM	¦
6169371403	SYNCHELIDIUM RECTIPA	61693714	SYNCHELIDIUM	¦
6169371498	NAME NOT FOUND	61693714	SYNCHELIDIUM	¦
6169371499	NAME NOT FOUND	61693714	SYNCHELIDIUM	¦
61693715	WESTWOODILLA	61693715	WESTWOODILLA	
6169371502	WESTWOODILLA CAECULA	61693715	WESTWOODILLA	
616942	PHOXOCEPHALIDAE	616942	PHOXOCEPHALIDAE	¦+
61694209	PARAPHOXUS	616942	PHOXOCEPHALIDAE	¦
6169420918	PARAPHOXUS ROBUSTUS	616942	PHOXOCEPHALIDAE	¦
6169420921	PARAPHOXUS MILLERI	616942	PHOXOCEPHALIDAE	¦
6169420924	PARAPHOXUS OBTUSIDEN	616942	PHOXOCEPHALIDAE	¦
6169420926	PARAPHOXUS VARIATUS	616942	PHOXOCEPHALIDAE	¦
6169420927	PARAPHOXUS EPISTOMUS	616942	PHOXOCEPHALIDAE	¦
6169420928	PARAPHOXUS SPINOSUS	616942	PHOXOCEPHALIDAE	¦
6169420997	NAME NOT FOUND	616942	PHOXOCEPHALIDAE	¦
6169420999	NAME NOT FOUND	616942	PHOXOCEPHALIDAE	¦
616943	PLEUSTIDAE	616943	PLEUSTIDAE	
61694303	PARAPLEUSTES	61694303	PARAPLEUSTES	¦+
6169430301	PARAPLEUSTES NAUTILU	61694303	PARAPLEUSTES	¦
6169430302	PARAPLEUSTES PUGETTE	61694303	PARAPLEUSTES	¦
6169430399	NAME NOT FOUND	61694303	PARAPLEUSTES	¦
61694304	PLEUSTES	61694304	PLEUSTES	¦+
6169430408	PLEUSTES DEPRESSA	61694304	PLEUSTES	¦
6169430499	NAME NOT FOUND	61694304	PLEUSTES	¦
61694305	PLEUSYMTES	61694305	PLEUSYMTES	
6169430501	PLEUSYMTES SUBGLABER	61694305	PLEUSYMTES	
6169430599	NAME NOT FOUND	61694305	PLEUSYMTES	
61694307	PLEUSIRUS	61694307	PLEUSIRUS	
6169430701	PLEUSIRUS SECORRUS	61694307	PLEUSIRUS	
6169439999	NAME NOT FOUND	616943	PLEUSTIDAE	
61694401	DULICHIA (AMPHIPO	61694401	DULICHIA (AMPHIPODA)	
6169440199	NAME NOT FOUND	61694401	DULICHIA (AMPHIPODA)	
61694404	PODOCERUS	61694404	PODOCERUS	
6169440401	PODOCERUS CRISTATUS	61694404	PODOCERUS	
6169440499	NAME NOT FOUND	61694404	PODOCERUS	
616948	STENOTHOIDAE	616948	STENOTHOIDAE	
61694811	STENOTHOIDES	616948	STENOTHOIDAE	
6169481102	STENOTHOIDES BERINGI	616948	STENOTHOIDAE	
61695005	TIRON	61695005	TIRON	
6169500502	TIRON BIOCULATA	61695005	TIRON	
61695101	ORCHESTIA	61695101	ORCHESTIA	

(continued)

TABLE B-3 (continued)

6169731499	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999978	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999979	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999987	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999989	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999990	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999991	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999992	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999997	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999998	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6169999999	NAME NOT FOUND	6169	GAMMARID AMPHIPOD	
6170010103	HYPERIA MEDUSARUM	6170010103	HYPERIA MEDUSARUM	
6171	PERACARIDA AMPHIPODA	6171	PERACARIDA AMPHIPODA CAPRELLIDEA	
617101	CAPRELLIDAE	617101	CAPRELLIDAE	
6171010201	DEUTELLA CALIFORNICA	6171010201	DEUTELLA CALIFORNICA	
61710104	METACAPRELLA	61710104	METACAPRELLA	¦+
6171010401	METACAPRELLA KENNERL	6171010401	METACAPRELLA KENNERLYI	¦
6171010402	METACAPRELLA ANOMALA	6171010402	METACAPRELLA ANOMALA	¦
6171010601	TRITELLA LAEVIS	6171010601	TRITELLA LAEVIS	
6171010602	TRITELLA PILIMANA	6171010602	TRITELLA PILIMANA	+
61710107	CAPRELLA (AMPHIPO	61710107	CAPRELLA (AMPHIPODA)	¦+
6171010708	CAPRELLA IRREGULARIS	6171010708	CAPRELLA IRREGULARIS	¦
6171010709	CAPRELLA GRACILIOR	6171010709	CAPRELLA GRACILIOR	¦
6171010710	CAPRELLA LAEVIUSCULA	6171010710	CAPRELLA LAEVIUSCULA	¦
6171010714	CAPRELLA FERREA	6171010714	CAPRELLA FERREA	¦
6171010715	CAPRELLA AUGUSTA	6171010715	CAPRELLA AUGUSTA	¦
6171010717	CAPRELLA CALIFORNICA	6171010717	CAPRELLA CALIFORNICA	¦
6171010719	CAPRELLA MENDAX	6171010719	CAPRELLA MENDAX	¦
6171010722	CAPRELLA STRIATA	6171010722	CAPRELLA STRIATA	¦
6175	EUCARIDA DECAPODA(AR	6175	EUCARIDA DECAPODA(ARTHROPODA)	
6179	EUCARIDA DECAPODA PL	6179	EUCARIDA DECAPODA PLEOCYEMATA CA	
617916	HIPPOLYTIDAE	617916	HIPPOLYTIDAE	
6179160102	HIPPOLYTE CLARKI	6179160102	HIPPOLYTE CLARKI	
61791602	SPIRONTOCARIS	61791602	SPIRONTOCARIS	
6179160201	SPIRONTOCARIS PRIONO	61791602	SPIRONTOCARIS	
61791603	LEBBEUS	61791603	LEBBEUS	
61791604	EUALUS	61791604	EUALUS	
6179160409	EUALUS HERDMANI	61791604	EUALUS	
61791605	HEPTACARPUS	61791605	HEPTACARPUS	
6179160501	HEPTACARPUS DECORA	6179160501	HEPTACARPUS DECORA	
6179160503	HEPTACARPUS STYLUS	6179160503	HEPTACARPUS STYLUS	
6179160506	HEPTACARPUS KINCAIDI	6179160506	HEPTACARPUS KINCAIDI	
6179160510	HEPTACARPUS BREVIROS	6179160510	HEPTACARPUS BREVIROSTRIS	*
6179160511	HEPTACARPUS STIMPSON	6179160511	HEPTACARPUS STIMPSONI	
6179160512	HEPTACARPUS PALUDICO	6179160512	HEPTACARPUS PALUDICOLA	
6179160517	HEPTACARPUS PALPATOR	6179160517	HEPTACARPUS PALPATOR	
61791801	PANDALUS	61791801	PANDALUS	
6179180104	PANDALUS MONTAGUI	6179180104	PANDALUS MONTAGUI	

(continued)

TABLE B-3 (continued)

6179180108	PANDALUS STENOLEPIS	6179180108	PANDALUS STENOLEPIS	
617922	CRANGON CALIFORNIENS	617922	CRANGON CALIFORNIENSIS	
61792201	CRANGON	61792201	CRANGON	
6179220101	CRANGON NIGRICAUDA	6179220101	CRANGON NIGRICAUDA	
6179220102	CRANGON ALASKENSIS	6179220102	CRANGON ALASKENSIS	
6179220106	CRANGON DALLI	6179220106	CRANGON DALLI	
6179220115	CRANGON MUNITELLA	6179220115	CRANGON MUNITELLA	
6179220116	CRANGON RESIMA	6179220116	CRANGON RESIMA	
6179220202	SCLEROCRANGON ALATA	6179220202	SCLEROCRANGON ALATA	
6179220302	ARGIS DENTATA	6179220302	ARGIS DENTATA	
618304	CALLIANASSIDAE	618304	CALLIANASSIDAE	
6183040101	UPOGEBIA PUGETTENSIS	6183040101	UPOGEBIA PUGETTENSIS	+
6183040204	CALLIANASSA CALIFORN	6183040204	CALLIANASSA CALIFORNIENSIS	
618306	PAGURIDAE	618306	PAGURIDAE	
61830601	PAGURISTES	61830601	PAGURISTES	
61830602	PAGURUS (DECAPODA)	61830602	PAGURUS (DECAPODA)	
6183060203	PAGURUS ALEUTICUS	6183060203	PAGURUS ALEUTICUS	
6183060205	PAGURUS CAPILLATUS	6183060205	PAGURUS CAPILLATUS	
6183060206	PAGURUS SETOSUS	6183060206	PAGURUS SETOSUS	
6183060207	PAGURUS KENNERLYI	6183060207	PAGURUS KENNERLYI	
6183060208	PAGURUS CAURINUS	6183060208	PAGURUS CAURINUS	
6183060209	PAGURUS BERINGANUS	6183060209	PAGURUS BERINGANUS	*
6183060213	PAGURUS HIRSUTIUSCUL	6183060213	PAGURUS HIRSUTIUSCULUS	
6183060223	PAGURUS DALLI	6183060223	PAGURUS DALLI	
6183060301	ELASSOCHIRUS TENUIMA	6183060301	ELASSOCHIRUS TENUIMANUS	
6183060303	ELASSOCHIRUS GILLI	6183060303	ELASSOCHIRUS GILLI	
6183060401	LABIDOCHIRUS SPLENDE	6183060401	LABIDOCHIRUS SPLENDESCENS	
6183060501	DISCORSOPAGURUS SCHM	6183060501	DISCORSOPAGURUS SCHMITTI	
6183080202	HAPALOGASTER MERTENS	6183080202	HAPALOGASTER MERTENSII	
6183080601	PHYLLOLITHODES PAPIL	6183080601	PHYLLOLITHODES PAPILLOSUS	
61830811	CRYPTOLITHODES	61830811	CRYPTOLITHODES	
6183081101	CRYPTOLITHODES SITCH	6183081101	CRYPTOLITHODES SITCHENSIS	
6183081102	CRYPTOLITHODES TYPIC	6183081102	CRYPTOLITHODES TYPICUS	
6183120101	PETROLISTHES ERIOMER	6183120101	PETROLISTHES ERIOMERUS	
6183120201	PACHYCHELES PUBESCEN	6183120201	PACHYCHELES PUBESCENS	
6184	EUCARIDA DECAPODA PL	6184	EUCARIDA DECAPODA PLEOCYEMATA BR	
618701	MAJIDAE	618701	MAJIDAE	
61870101	OREGONIA	61870101	OREGONIA	|+
6187010101	OREGONIA GRACILIS	61870101	OREGONIA	|
6187010201	HYAS LYRATUS	6187010201	HYAS LYRATUS	
6187010401	MIMULUS FOLIATUS	6187010401	MIMULUS FOLIATUS	
61870105	PUGETTIA (DECAPODA	61870105	PUGETTIA (DECAPODA)	
6187010501	PUGETTIA PRODUCTA	6187010501	PUGETTIA PRODUCTA	
6187010502	PUGETTIA RICHII	6187010502	PUGETTIA RICHII	*
187010503	PUGETTIA GRACILIS	6187010503	PUGETTIA GRACILIS	*
6187010701	SCYRA ACUTIFRONS	6187010701	SCYRA ACUTIFRONS	
6188	EUCARIDA DECAPODA PL	6188	EUCARIDA DECAPODA PLEOCYEMATA BR	
6188020101	TELMESSUS CHEIRAGONU	6188020101	TELMESSUS CHEIRAGONUS	

(continued)

TABLE B-3 (continued)

61880301	CANCER	61880301	CANCER	
6188030101	CANCER PRODUCTUS	6188030101	CANCER PRODUCTUS	
6188030103	CANCER BRANNERI	6188030103	CANCER BRANNERI	
6188030104	CANCER MAGISTER	6188030104	CANCER MAGISTER	
6188030105	CANCER GRACILIS	6188030105	CANCER GRACILIS	
6188030106	CANCER OREGONENSIS	6188030106	CANCER OREGONENSIS	*
6189020101	LOPHOPANOPEUS BELLUS	6189020101	LOPHOPANOPEUS BELLUS	
6189020301	FABIA SUBQUADRATA	6189020301	FABIA SUBQUADRATA	
6189020403	NAME NOT FOUND	618902	XANTHIDAE	
618906	PINNOTHERIDAE	618906	PINNOTHERIDAE	
61890604	PINNIXA	61890604	PINNIXA	|+
6189060402	PINNIXA LITTORALIS	6189060402	PINNIXA LITTORALIS	|
6189060403	PINNIXA OCCIDENTALIS	6189060403	PINNIXA OCCIDENTALIS	|
61890701	HEMIGRAPSUS	61890701	HEMIGRAPSUS	
6189070101	HEMIGRAPSUS NUDUS	6189070101	HEMIGRAPSUS NUDUS	
6189070102	HEMIGRAPSUS OREGONEN	6189070102	HEMIGRAPSUS OREGONENSIS	
6189070301	SCLEROPLAX GRANULATA	6189070301	SCLEROPLAX GRANULATA	
628403	CICADELLIDAE	628403	CICADELLIDAE	
6501	DIPTERA	6501	DIPTERA	
650508	CHIRONOMIDAE	650508	CHIRONOMIDAE	
65160112	ATYLOTUS	65160112	ATYLOTUS	
72	SIPUNCULIDA	72	SIPUNCULIDA	
7200	NAME NOT FOUND	72	SIPUNCULIDA	
72000201	GOLFINGIA	72000201	GOLFINGIA	
7200020103	GOLFINGIA VULGARIS	7200020103	GOLFINGIA VULGARIS	
7200020104	GOLFINGIA PUGETTENSI	7200020104	GOLFINGIA PUGETTENSIS	
7200040101	PHASCOLOSOMA AGASSIZ	7200040101	PHASCOLOSOMA AGASSIZII	
74000101	PRIAPULUS	74000101	PRIAPULUS	
7400010101	PRIAPULUS CAUDATUS	74000101	PRIAPULUS	
77	PHORONIDA	77	PHORONIDA	
770001	PHORONIDAE	770001	PHORONIDAE	
7700010102	PHORONOPSIS HARMERI	77000101	PHORONOPSIS	
7700010199	NAME NOT FOUND	77000101	PHORONOPSIS	
77000102	PHORONIS	77000102	PHORONIS	
7700010201	PHORONIS VANCOUVEREN	77000102	PHORONIS	
78	ECTOPROCTA	78	ECTOPROCTA	
7809	GYMNOLAEMATA CYCLOST	7809	GYMNOLAEMATA CYCLOSTOMATA ARTICU	
78100201	TUBULIPORA	78100201	TUBULIPORA	
78120101	HETEROPORA (ECTOP	78120101	HETEROPORA (ECTOPROCT)	
7812010102	HETEROPORA PACIFICA	78120101	HETEROPORA (ECTOPROCT)	
7812010199	NAME NOT FOUND	78120101	HETEROPORA (ECTOPROCT)	
7814	GYMNOLAEMATA CHEILOS	7814	GYMNOLAEMATA CHEILOSTOMATA	
78150401	MEMBRANIPORA	78150401	MEMBRANIPORA	
78150801	CALLOPORA	78150801	CALLOPORA	
78152502	DENDROBEANIA	78152502	DENDROBEANIA	
78161302	SMITTINA (ECTOPROC	78161302	SMITTINA (ECTOPROCTA)	
8005110201	TEREBRATALIA TRANSVE	8005110201	TEREBRATALIA TRANSVERSA	
8113010304	SOLASTER STIMPSONI	8113010304	SOLASTER STIMPSONI	

(continued)

TABLE B-3 (continued)

8114030101	DERMASTERIAS IMBRICA	8114030101	DERMASTERIAS IMBRICATA	
811703	ASTERIIDAE	811703	ASTERIIDAE	
8117030409	LEPTASTERIAS HEXACTI	8117030409	LEPTASTERIAS HEXACTIS	+
8117030502	PISASTER OCHRACEUS	8117030502	PISASTER OCHRACEUS	
8117031001	ORTHASTERIAS KOEHLER	8117031001	ORTHASTERIAS KOEHLERI	
8120	OPHIUROIDEA	8120	OPHIUROIDEA	
812701	OPHIURIDAE	812701	OPHIURIDAE	
8129	OPHIUROIDEA OPHIURID	8129	OPHIUROIDEA OPHIURIDA GNATHOPHIU	
8129020101	OPHIOPHOLIS ACULEATA	8129020101	OPHIOPHOLIS ACULEATA	
812903	AMPHIURIDAE	812903	AMPHIURIDAE	
81290301	AMPHIODIA	81290301	AMPHIODIA	
81290302	AXIOGNATHUS	81290302	AXIOGNATHUS	
8129030299	NAME NOT FOUND	81290302	AXIOGNATHUS	
8136	ECHINOIDEA	8136	ECHINOIDEA	
81490302	STRONGYLOCENTROTUS	81490302	STRONGYLOCENTROTUS	
8149030201	STRONGYLOCENTROTUS D	8149030201	STRONGYLOCENTROTUS DROEBACHIENSI	
8149030202	STRONGYLOCENTROTUS F	8149030202	STRONGYLOCENTROTUS FRANCISCANUS	
8149030203	STRONGYLOCENTROTUS P	8149030203	STRONGYLOCENTROTUS PALLIDUS	
8149030204	STRONGYLOCENTROTUS P	8149030204	STRONGYLOCENTROTUS PURPURATUS	
8155010101	DENDRASTER EXCENTRIC	8155010101	DENDRASTER EXCENTRICUS	
8170	HOLOTHUROIDEA	8170	HOLOTHUROIDEA	
8172	HOLOTHUROIDEA DENDRO	8172	HOLOTHUROIDEA DENDROCHIROTACEA D	
8172030201	PSOLUS CHITINOIDES	8172030201	PSOLUS CHITINOIDES	
817206	CUCUMARIIDAE	817206	CUCUMARIIDAE	
81720601	CUCUMARIA	81720601	CUCUMARIA	
8172060109	CUCUMARIA LUBRICATA	8172060109	CUCUMARIA LUBRICATA	
8172060110	CUCUMARIA MINIATA	8172060110	CUCUMARIA MINIATA	
81720602	EUPENTACTA	81720602	EUPENTACTA	
8172060201	EUPENTACTA PSEUDOQUI	8172060201	EUPENTACTA PSEUDOQUINQUESEMITA	
8172060202	EUPENTACTA QUINQUESE	8172060202	EUPENTACTA QUINQUESEMITA	
81720603	PENTAMERA	81720603	PENTAMERA	
8172060599	NAME NOT FOUND	81720605	THYONE	
8175020101	PARASTICHOPUS CALIFO	8175020101	PARASTICHOPUS CALIFORNICUS	
81780102	LEPTOSYNAPTA	81780102	LEPTOSYNAPTA	¦ *
8178010203	LEPTOSYNAPTA CLARKI	81780102	LEPTOSYNAPTA	¦
8179	HOLOTHUROIDEA APODAC	8179	HOLOTHUROIDEA APODACEA MOLPADIID	
817901	MOLPADIIDAE	8179	HOLOTHUROIDEA APODACEA MOLPADIID	
8179010101	MOLPADIA INTERMEDIA	8179	HOLOTHUROIDEA APODACEA MOLPADIID	
8201	ENTEROPNEUSTA	8201	ENTEROPNEUSTA	
8300000303	SAGITTA ELEGANS	8300000303	SAGITTA ELEGANS	
84	UROCHORDATA	84	UROCHORDATA	
8401	ASCIDIACEA	8401	ASCIDIACEA	
8403010401	ARCHIOISTOMA RITTERI	8403010401	ARCHIOISTOMA RITTERI	
8404040102	CHELYOSOMA PRODUCTUM	8404040102	CHELYOSOMA PRODUCTUM	
8404040202	CORELLA WILLMERIANA	8404040202	CORELLA WILLMERIANA	
8406010201	METANDROCARPA DURA	8406010201	METANDROCARPA DURA	
8406010302	CNEMIDOCARPA FINMARK	8406010302	CNEMIDOCARPA FINMARKIENSIS	
8406010505	STYELA GIBBSII	8406010505	STYELA GIBBSII	

(continued)

TABLE B-3 (continued)

8406020101	PYURA HAUSTOR	8406020101	PYURA HAUSTOR	
8406020203	BOLTENIA VILLOSA	8406020203	BOLTENIA VILLOSA	
8717	OSTEICHTHYES	8717	OSTEICHTHYES	
8784010101	GOBIESOX MAEANDRICUS	8784010101	GOBIESOX MAEANDRICUS (NORTHERN C	
8831070101	PSYCHROLUTES PARADOX	8831070101	PSYCHROLUTES PARADOXUS (TADPOLE	
8831090803	LIPARIS CALLYODON (S	8831090803	LIPARIS CALLYODON (SPOTTED SNAIL	
88421302	PHOLIS	88421302	PHOLIS	
8842130205	PHOLIS LAETA (CRESCE	88421302	PHOLIS	
99990001	NAME NOT FOUND	ER		
999999	NAME NOT FOUND	ER		
ABIOTIC	NAME NOT FOUND	ABIOTIC	NONE OF THESE TAXA	*

APPENDIX C

ANIMALS AND PLANTS FOUND AT COBBLE SITES

The tabulation which comprises this appendix includes animals and plants found at cobble sites. The total number of samples in which each occurred and the number at each site, date, and elevation stratum are tabulated.

The elevation strata for this tabulation are defined as low, -1 m to +0.4 m; mid, +0.5 m to +1.4 m; and high, greater than +1.4 m. The station codes used in the tabulation are

1012	Cherry Point (NPS),
2016	Morse Creek (Strait),
2050	North Beach (Strait),
2063	Partridge Point (Whidbey), and
3064	South Beach (SJI).

Shannon Point is not included because it was one of the sites where only gradient sampling during the first year of the NPS study was done and only 2-mm fractions were fully processed. Live sieve data are also omitted since they are not available for Cherry Point.

(Pages 263-310 microfiched)